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JUNE
1953

IN THIS ISSUE . . .

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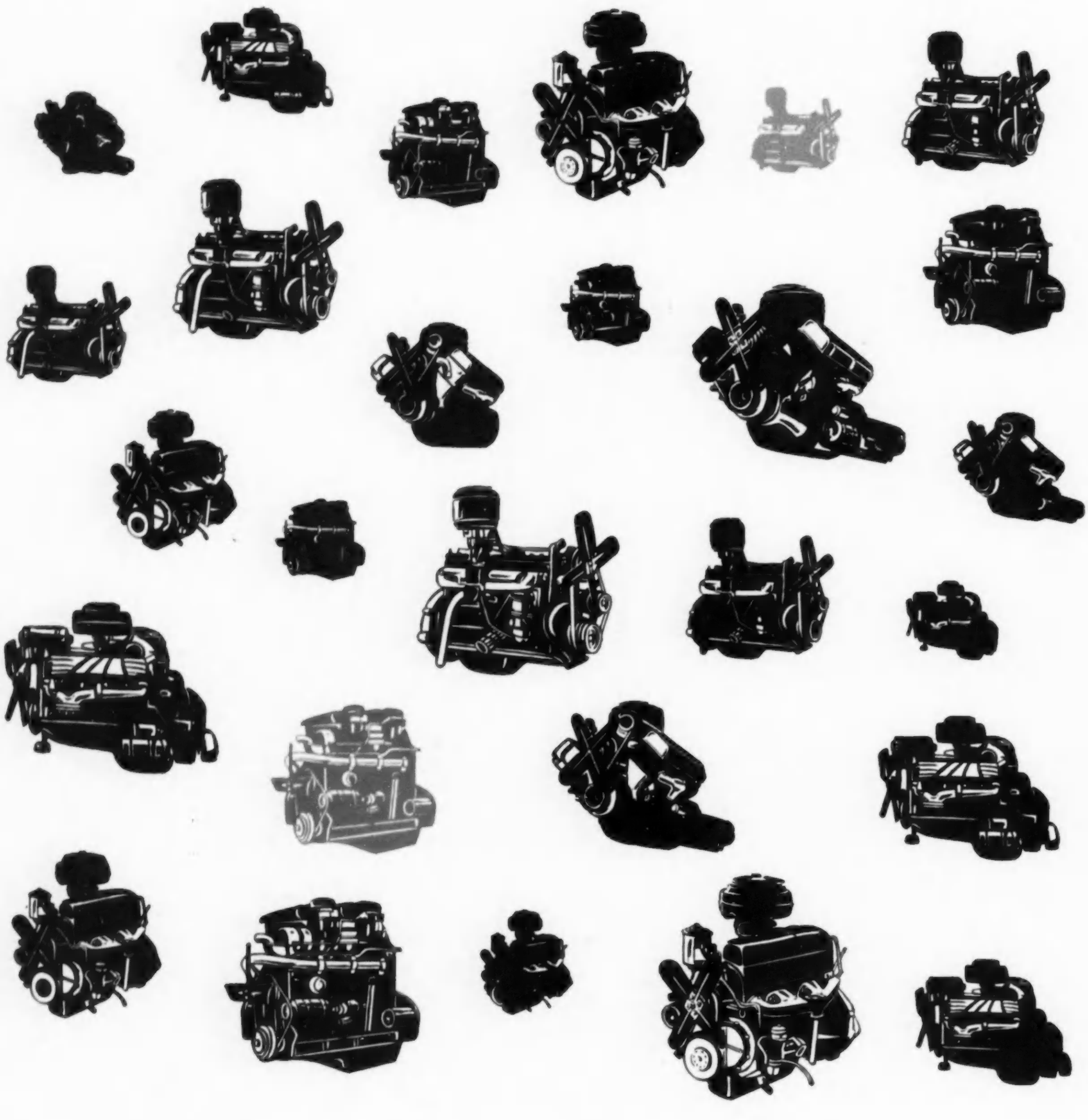

This wonder weapon can detect an approaching enemy aircraft 15 miles (90 seconds) away and blast it out of the sky. The *Skysweeper* automatically gauges the speed and course of the oncoming target and fires proximity-fused shells to bring down the plane.

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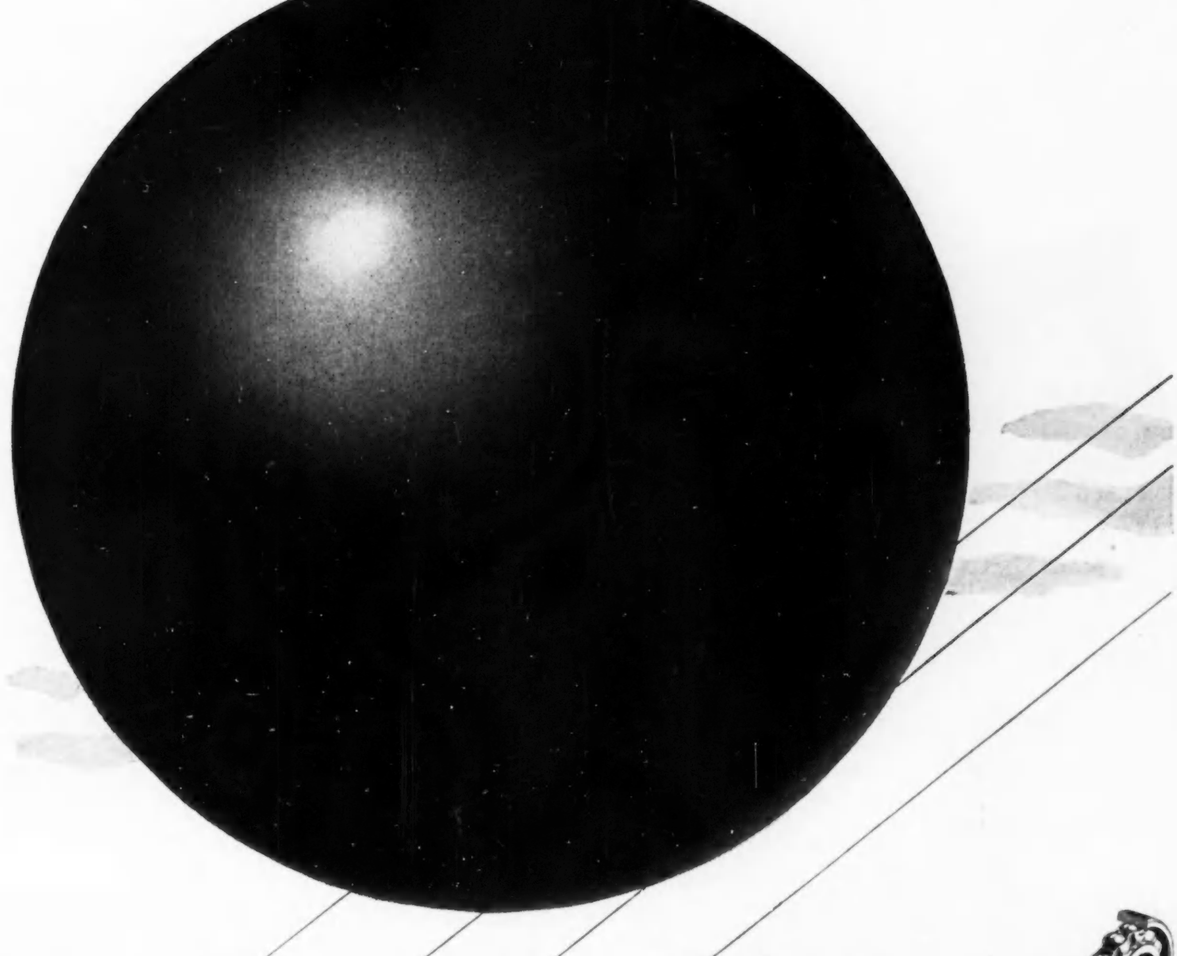

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BALL BEARINGS

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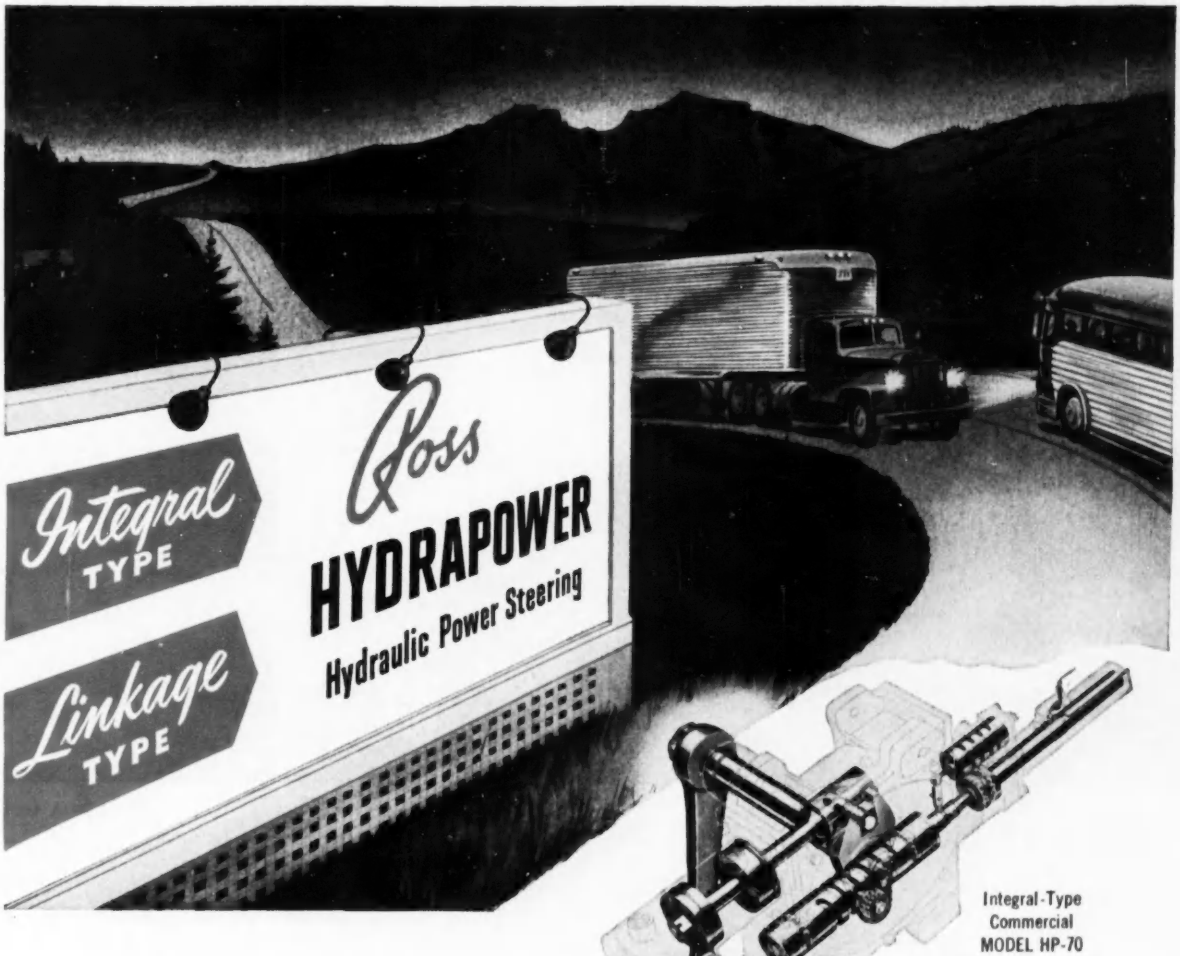

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Buses, trucks, tractors, passenger cars, heavy-duty work vehicles—*all* set new performance standards with *effortless, fatigueless* Ross HYDRAPOWER.

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Ross HYDRAPOWER is the product of Ross Gear & Tool Company, *exclusive steering specialists* for nearly a half century. Ross Cam & Lever Steering is in service on a greater variety of vehicles than any other make. We invite discussion of *any* steering problem.

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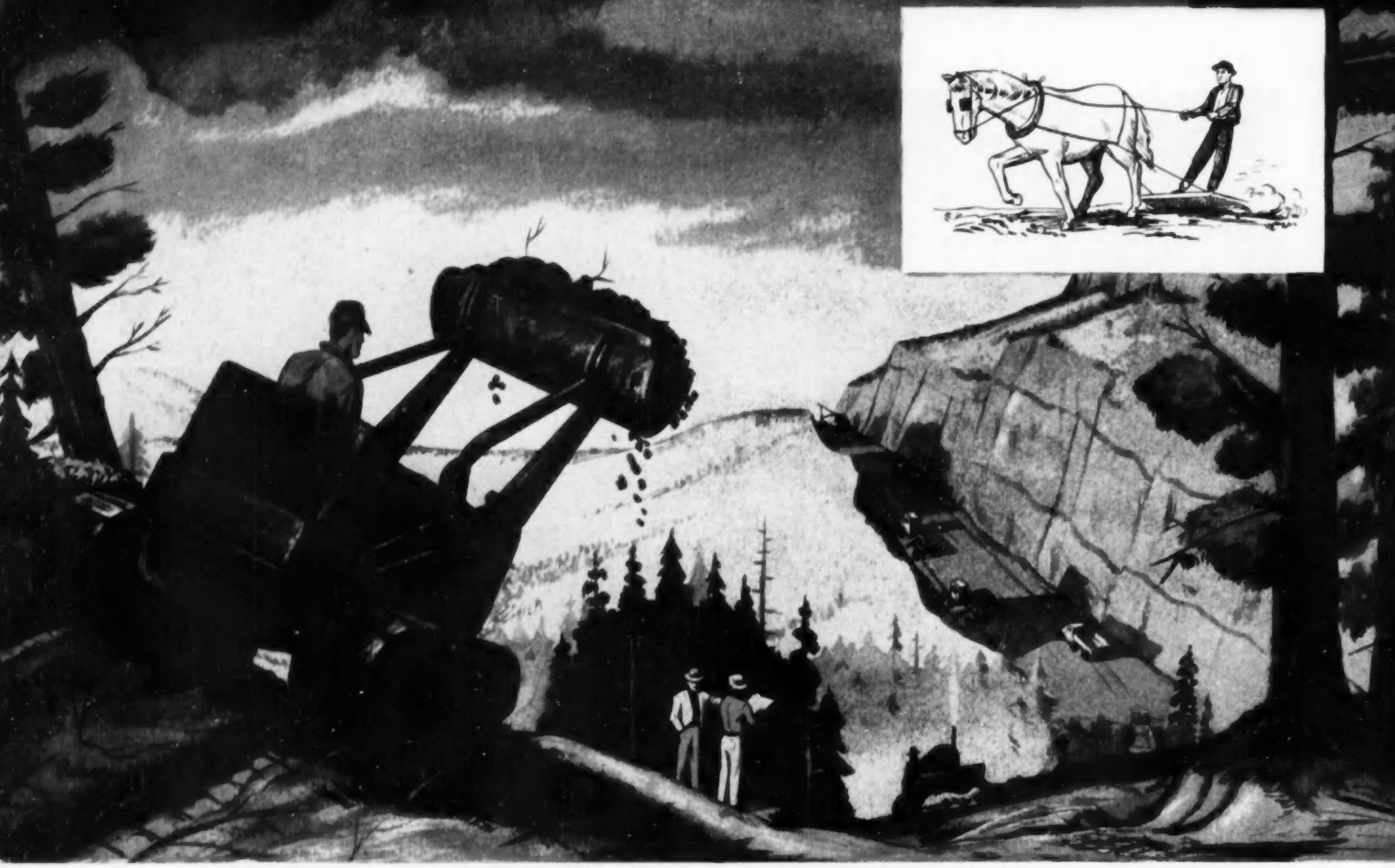

ONE OF A SERIES

On Our Golden Anniversary we salute the . . . . .

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In the early 1900's the young automotive industry was bogging down in the mire of poor roads. Road building engineers envisaged the answer, and the construction equipment industry helped make their visions a reality, carving and leveling the earth for today's multilane expressways.

Road building is only one of the many contributions to better living being made by the construction equipment industry. In real estate development, contour farming, dam building, irrigation, rail line extension, mining, and many other fields, these powerful earth moving machines are overcoming the obstacles of nature.

Burgess-Norton is proud of the part their piston pins, crawler type track bushings, and other precision parts have had over the years in adding to the dependable performance of this construction equipment.

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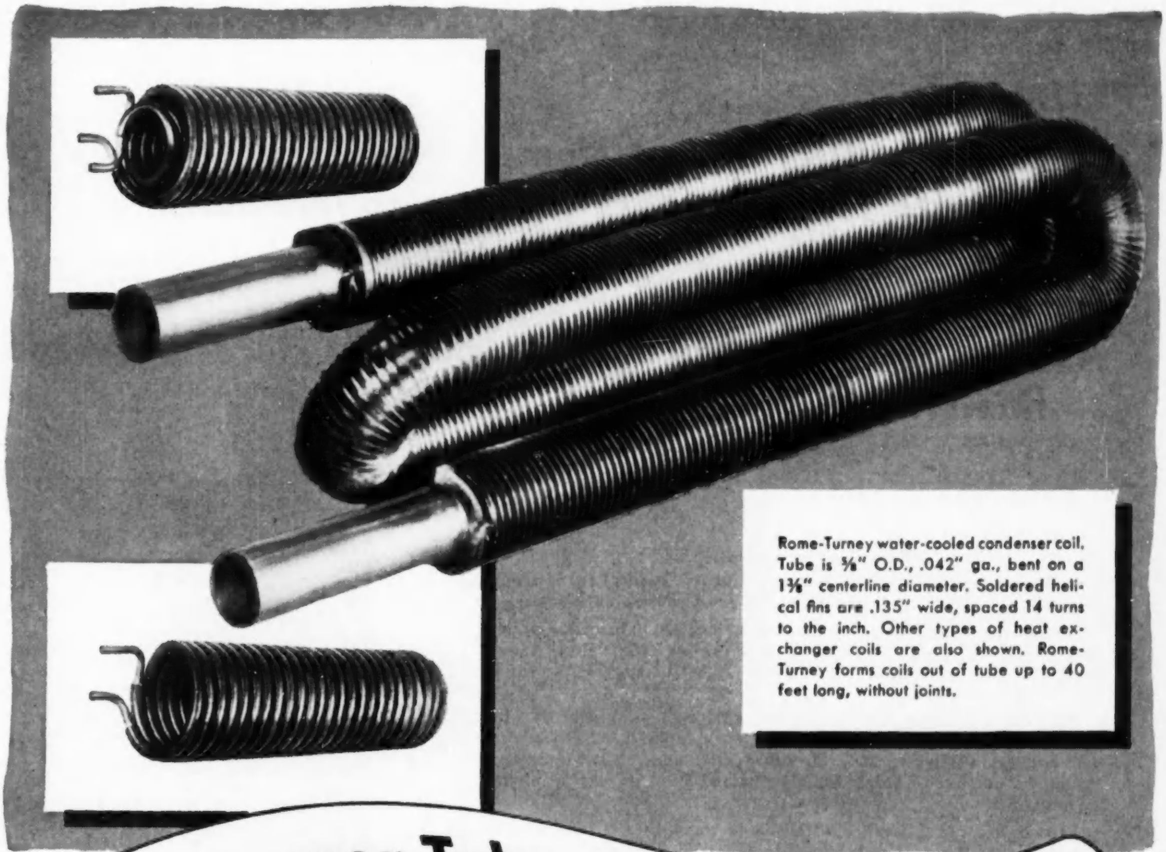

Rome-Turney water-cooled condenser coil. Tube is ⅝" O.D., .042" ga., bent on a 1⅜" centerline diameter. Soldered helical fins are .135" wide, spaced 14 turns to the inch. Other types of heat exchanger coils are also shown. Rome-Turney forms coils out of tube up to 40 feet long, without joints.

For Copper Tube that can be BENT

Rome-Turney sees REVERE

Most of the Revere Metals are fabricated by usual methods into conventional products. Some of them, however, appear on the market in forms that are unusual and possess special advantages. Take these helical-finned copper coils produced by the Rome-Turney Radiator Co., Rome, N. Y. It takes extra skill to produce coils with such small radii. The company can produce the coils shown on a commercial basis, for use in air conditioning apparatus, air compressors, and general heating and cooling applications where compactness plus high heat transfer rates are essential.

How it is possible to make such tight turns is Rome-Turney's secret. Revere does not share in it, nor does Revere want to reveal a secret of its own, which is how we turn out copper tube in a special bending temper for an application such as this. All we can say is that the two methods dovetail very nicely. If you need copper tube that can be bent easily, and offers you as well the advantages of corrosion resistance, high heat transfer, easy joinings, see Revere. We also make copper pipe, tube in copper alloys, aluminum alloys, and electric welded steel tube. If required, the Technical Advisory Service will gladly collaborate with you, as it has with Rome-Turney, on selection and specification matters. Get in touch with the nearest Revere Sales Office.

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PROBLEM:

To get a Thermostat Element with the stability to operate for 100 years without calibration

SOLUTION:

General Plate TRUFLEX® Thermostat Metal provided this stability

The Museum of Science and Industry laid its "living" cornerstone September 3, 1952, thus starting a one hundred year experiment.

Within the 1-ton limestone block is a specially fabricated monel box containing a score of physically or biologically "alive" items from bacteria to metals . . . including a thermostatic clock which will record the years.

This clock is constructed to register once as the temperature falls to 20°F and will not count again until the temperature has risen to 85° and again fallen to 20°. It will register once each winter and count the number of years that have passed since the laying of the cornerstone.

Essential to the reliability of the clock was a thermostat element which would keep its stability without further calibration for 100 years.

The scientist concerned with the project presented the problem to General Plate whose engineers provided the solution with a specially designed Truflex thermostat metal element.

You, too, can obtain constant and accurate performance in your products because General Plate fabricates to your exact specifications, complete Truflex thermostat metal units ready for installation. You get reliable performance because every order comes to you an exact duplicate of the original . . . consistently uniform in tolerances, temperature reaction and performance, thus preventing rejects and costly adjustments in assembly.

General Plate TRUFLEX thermostat metal assemblies are made to meet your specific requirements for temperature range, electrical resistance, corrosion resistance, etc. If you prefer to make your own assemblies, General Plate will produce Truflex thermostat metal sheet or strip to your material specifications. Write for information or engineering assistance.

You can profit by using General Plate Composite Metals!

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For the Sake of Argument

When is a Discussion an Argument?

By Norman G. Shidle

A discussion becomes an argument when the people involved stop trying to convince each other and each concentrates on justifying his own point of view. That's when reasons are replaced by rationalizations.

True, it takes two to make an argument—but only a single person to start one. Two are needed only in the sense that an argument can't go on when one party goes away—mentally or physically—and stops participating. . . . But the argument starts when one person makes a statement which provides *feeling* rather than thought on the part of the other.

The argument-starting statement is always subjective. The person making it is thinking first of himself; last, if at all, of his audience. The statement is always made without crystal-clear definition of purpose. If its aim really were to convince another person or group, it probably never would have been made. (It's pretty obvious that arousing emotional opposition isn't the shortest road to convincement.)

The Quakers speak of people of non-Quaker parentage who join their Meetings as "Convinced Quakers." And their experience is that the "convincement" must be a process undertaken and achieved by the person to be convinced. No Quaker will ever try to convince him. Either he convinces himself or stays unconvinced.

So is the case likely to be in any discussion between people or groups. However much we may wish to have our point of view accepted by others, the actual acceptance must be accomplished inside the others. Conviction can come only with acceptance—and acceptance is a function of the "acceptee," not of an outsider.

So, a true discusser will be thinking first of the other fellow's probable needs, reactions, and desires. Only the arguer will be thinking of his own.

And the reverse is true. When our talk springs from our own likes and dislikes, we are on our way to an argument. When it springs from our consideration of others, we may be in for an interesting discussion.

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Contents—June 1953

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for

The Only Performance-Proven Low Pedal Power Brake

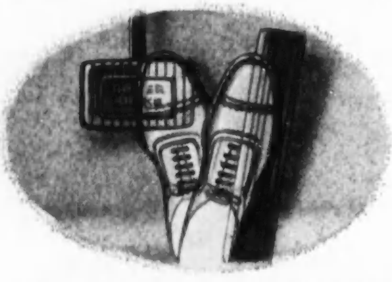
Car manufacturers, here is a sure answer to the problem of creating added interest in your line of cars. Equip your vehicles with Bendix* Low Pedal Power Brake, the sales feature that has already established itself as one of the most popular devices offered the public in years.

Dealers are enthusiastic because with the Bendix Low Pedal Power Brake it is now easy to demonstrate added braking power and safety. Service managers are happy because of its trouble-free performance and, best of all, new car buyers realize that with today's trend toward "power" operation, a car equipped with a Bendix Low Pedal Power Brake offers the ultimate in braking efficiency.

Remember, too, this new low pedal power brake is the product of Bendix, world's largest producer of power brakes and leader in braking developments since the earliest days of the industry. That's why if you are contemplating power braking it will pay to "Sign Up" with Bendix for the greatest improvement in braking since four wheel brakes.

*REG. U.S. PAT. OFF.

NOW *Stopping* **IS AS EASY AS** *accelerating*



It is no longer necessary to lift the foot and exert leg power pressure to bring your car to a stop. With the Bendix Low Pedal Power Brake on about the same level as the accelerator, an easy ankle movement, much like working the accelerator, is all the physical effort required for braking. And by merely pivoting the foot on the heel, shifts from "go" to "stop" controls are made in far less time.

Result: **MORE DRIVING COMFORT, LESS FATIGUE AND GREATER SAFETY.**

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THE MOST TRUSTED NAME IN BRAKING

Dual-Purpose Plant To Make Cars . . . and Jets!

John F. Gordon, General Motors Corp.

Based on paper, "Guns and Butter—A Plan for National Defense," presented at SAE Detroit Section Meeting, Nov. 17, 1952.

A VERSATILE ASSEMBLY PLANT will soon be able to turn out jet planes and passenger cars simultaneously . . . or switch over to total production of either one on short notice. Located in Kansas City, this "dual-purpose" plant is part of the government program to stretch defense dollars and still achieve utmost flexibility in defense and civilian production.

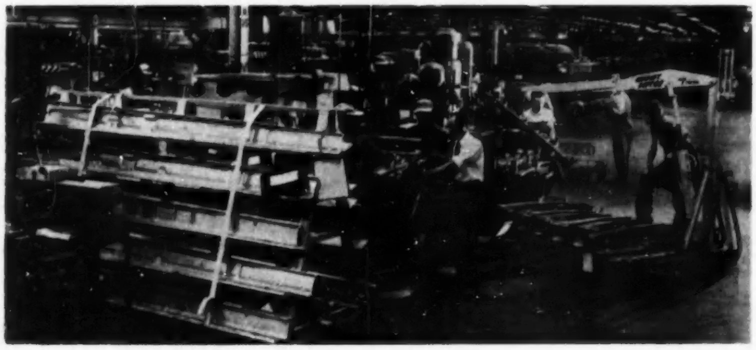
It's sure to save taxpayers' money because duplication of standard production facilities will be eliminated. There'll be no need for separate offices, drafting rooms, power plant, receiving and shipping facilities, railroad sidings, parking areas, hospital, tool rooms, and maintenance areas.

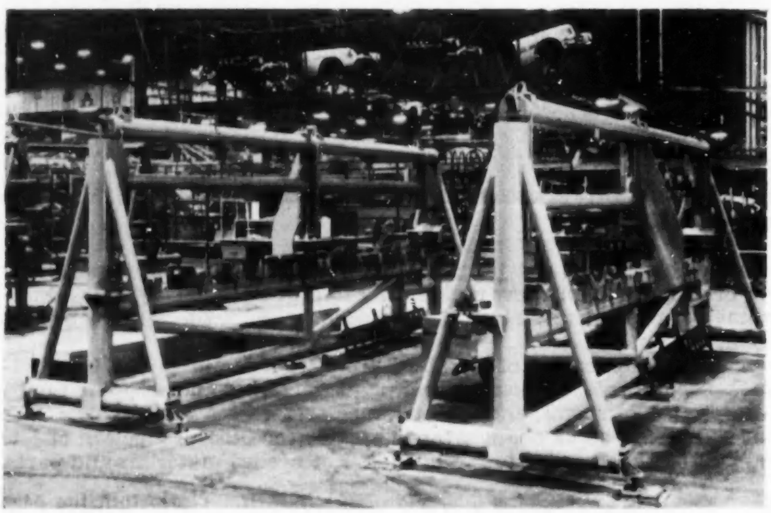
What's more, this dual-purpose plant will permit quick changeover to greater (or full) production of jets or cars. About the only time required will be that needed to establish flow of needed materials and parts.

Please turn the page

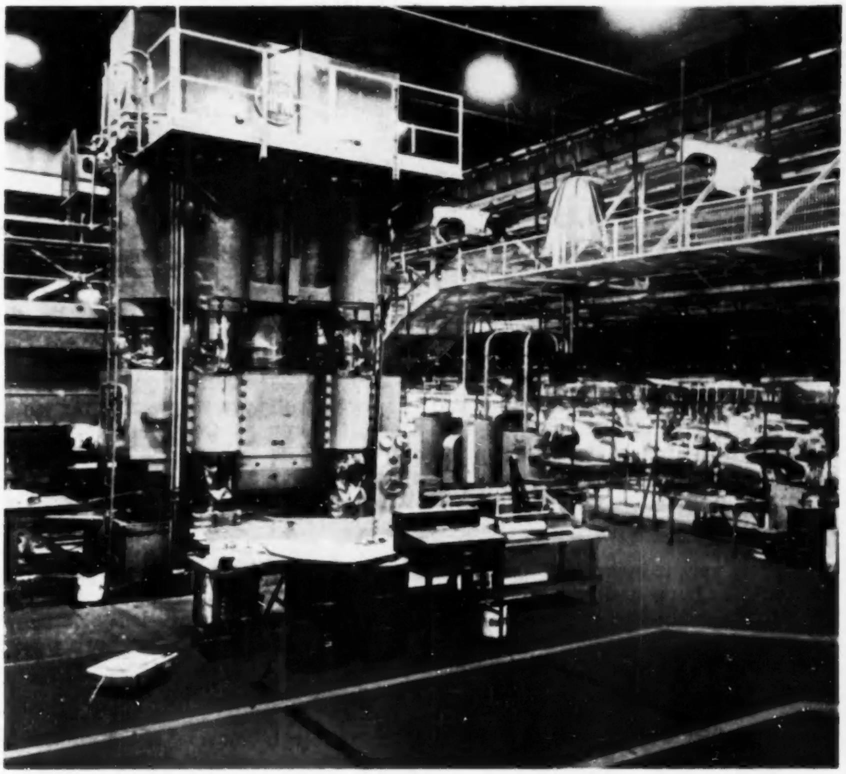
CONVERSION of this high bay portion of the plant to airplane assembly is now underway. The relatively little heavy equipment in this area makes for simple and quick changeover.

MACHINING of some wing forgings will be done on this equipment. Only a few months ago the automobile body trim department was located here.

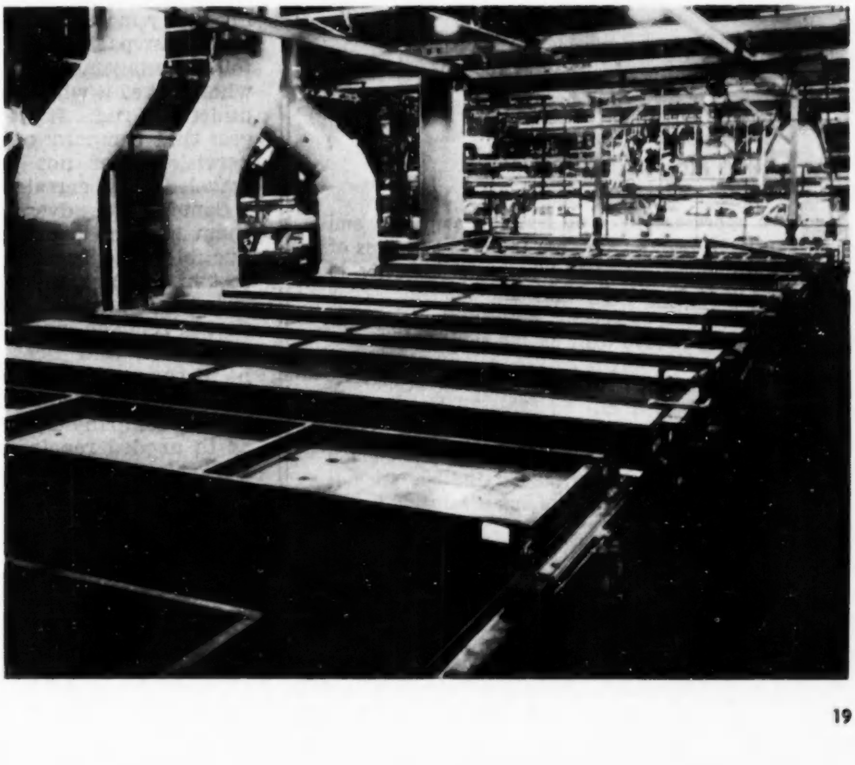




WING FIXTURES have been set up next to an "automotive" area. Note the conveyor carrying car front-end assemblies in the background.



STANDBY EQUIPMENT such as this large rubber press has been installed so that it will be ready for quick use when needed.



TANKS for anodizing sheet metal aircraft parts will be kept on hand regardless of production requirements. That's because they, too, reduce "make-ready" time.

Is It Better to Lease or Own

LONG term leasing of passenger cars and trucks has had a rapid development and is now a well established business, proof that many users of motor vehicles find it a satisfactory practice. But is it more economical than owning your own equipment? This is the question over which a controversy has raged for several years without yielding a specific answer.

Leasing versus ownership can hardly be discussed without making a distinction between passengers and trucks, although the arguments for and against often cover both categories. And since passenger cars come in for the greatest amount of discussion, the question as it relates to them will be discussed first.

Faced with the use of cars for business travel, management has these questions to answer, according to Pratt. Who is going to supply the car, the company or the employee? If the former, then what make and model of car? Will he be faced with reciprocal purchasing? What is fair compensation for use of an employee's car? Pratt considers employee ownership the least desirable of all plans.

There Are Many "If's"

Two representatives of leasing companies and two fleet operators discuss the pros and cons of the oft argued question whether it is better to lease or to own motor vehicle equipment. They come up with no specific answer, though shedding much needed light on the subject.

Three out of four agree that greater economies in transportation can be achieved by company ownership if there is sufficient capital or credit, if there are enough vehicles involved and enough miles traveled per year, and if the operation is controlled by a qualified administrator.

Call this an area of agreement if you will. Still to be agreed upon are: how much capital or credit, how many vehicles and how many miles.

Company ownership, he maintains, has certain advantages among which are:

Complete control of make, model, point of purchase, cycle of replacement, repairs, garaging, types of maintenance, and initial and replacement costs insofar as market permits; also control as to personal or family use.

Among disadvantages he lists: capital investment, which might better be used in the business to produce a profit rather than an expense, even though deductible for tax purposes; varying prices in cities where purchased, and varying taxes and license fees.

Pratt does not believe that very large fleets can be operated as economically under leasing as they can be if company owned, but just what constitutes a large fleet is open to question. Whether it comprises several thousand or several hundred depends entirely on point of view. He defines a large fleet as one headed by a qualified director on management level, who has a staff under his direction for proper administration of its operations. In fleets that do not justify such an individual, the burden of administration is usually laid upon someone having heavy managerial responsibilities. This usually results in part-time administration, or worse yet, joint management by several individuals, each of whom takes a whirl at it, and often just sweeps it under the rug. It would be idle, he adds, to suggest that company ownership under intelligent supervision does not produce lower cost per mile traveled, with certain limitations.

Some of the advantages of leasing as he outlines them are: no capital investment, entire cost deductible as operating expense, close budgeting of cost in advance, reduction of administrative supervision, entire maintenance cost included in rental, no tax problem, no limitations as to family or personal use, and fleet uniformity. On the other hand there are some disadvantages: control is not complete, since control of expense is vested in the leasing company there may be differences of opinion as to needed repairs, and there is the accounting work required to segregate expenses chargeable to lessee and lessor, under the contract terms.

Mathews tells of leasing employee cars at a 6¢ per mile rate which covers all costs but tolls, special parking and storage expense. To match this a leasing company quoted 9¢, basing on an average of 15,000 miles per year, and covering costs of gasoline, public liability and property damage insurance. While acknowledging that a lower contract price

Automotive Equipment?

might be had, he believes no contract possible where the total cost would be equal to, or less than, the 6¢ rate. The cost of operating company owned cars is slightly more than 4¢ a mile, hence leasing costs are too far out of line to be considered.

Leasing companies do not want to take the bad with the good, the author maintains. He cites having a number of cars used by livestock buyers who run up high mileage, about 30% of which is off the road. This use creates unusual wear and the leasing companies expect to be paid excessive rates. As now handled, these cars are included in company overall costs and considered a regular part of the fleet.

Apropos of this, Pratt, as a lessee says leasing companies were once concerned over mileage but have learned that mileage as such is not so important as the kind of mileage. So, careful studies are made of fleets in advance to determine who will use the cars—engineers, professional men, college graduates—and what the age group. All of this has bearing on the kind of car to be disposed of a year later. Lessees have learned what fleets to avoid and they shy from those used in oil fields or handled by the young age group which frequently harbors "hot-rodders". When the "dogs" show up, the company counsels with management, just as it does when expenses become excessive.

The company owned operation is by far the best, in Gardner's opinion, but he adds these qualifications: if the capital is obtainable, if enough vehicles and miles are involved, and if adequate control can be had. He decries the claims put forward by the leasing companies because he contends they can be matched by company ownership. Costs can be budgeted in advance; leasing costs have no tax deductible advantage. Bookkeeping cannot be done away with under any system. You still have to watch salesmen's expense accounts. Fleets can be just as reliable and replaced just as easily when owned. And there is no more cause for friction over restricted use.

Getting down to cases and to costs, Gardner compares costs to the advantage of company ownership. Itemizing company owned costs he arrives at a per car figure of $1011. To lease a comparable car would cost $740 per year, but to this figure must be added $502 to cover gasoline, storage, tolls, meters and insurance, which adds up to $1242. According to his figures there is a saving of $231 per car per 20,000 miles of travel yearly in favor of the company owned car.

There are many distinct advantages in the long term leasing of trucks, according to Willett. It saves the time of company executives; they can give their time to the business proper. Delivery expenses can be budgeted in advance. There are no maintenance worries; service is continuous because spare trucks are always in readiness. The fleet is always up to date, and capital is released for productive use. Leasing companies start with an advantage over the small truck user because they can buy at a discount.

Distribution trucks do present an entirely different problem from passenger cars in Mathews' opinion. In his operation, three sizes of trucks are used, ranging from 14,000 to 22,000 lb gross weight,

Based on papers:

Truck Leasing

By H. L. Willett, Jr.
National Truck Leasing System

How Vehicle Leasing Fits into the Transportation Picture

By E. C. Pratt
Fleet Leasing of Detroit

Leasing vs. Company Ownership of Automotive Equipment

By H. O. Mathews
Armour & Co.

Leasing vs. Company Ownership

By Robert Gardner

Presented at SAE Cleveland Section Meeting, Cleveland, October 13, 1952.

These papers are available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers.

and equipped with insulated and refrigerated bodies. The body and refrigeration equipment may represent a greater initial investment than the truck itself and leasing companies find it difficult to calculate a rate that will not appear to be excessive, yet reflect the investment on a fair basis to the user. Leasing is carried on in some cities satisfactorily, but the author notes that the rates quoted in some other cities, where they don't operate, are 100% higher.

It's fallacious, he thinks, to include garaging cost in leasing rates since this raises the cost above company ownership. Indoor garaging is not essential and if the charges were eliminated the leasing rates would be more attractive. The high capital investment of these refrigerated trucks is a serious problem and Mathews would be only too glad to switch to leasing if attractive rates could be had.

The author recommends looking into the leasing of over-the-road equipment. The cost of such leases can be measured against the results of private carrier cost against common carrier cost and in many cases sufficient saving can be made by diverting traffic to your own trucks, even though leased, so that any excessive cost you might feel you are paying for leased equipment would be offset by the savings made by moving your own goods.

By way of example: if there is a two way haul and the rate is $1.00 per cwt each way, you would pay on a 20,000 lb load a $400 transportation cost from which savings could be measured. To lease, hire a driver, and run the truck could easily produce a saving of 50% or $200 per trip. While you might be able to own the equipment for less than leasing it, you must remember that it would involve an investment of around $15,000 to buy the tractor and trailer and such capital could in many cases be used to greater advantages in the business.

Combustion-Chamber Deposits . . .

. . . create pressing problem because of increasing antiknock requirements. Elimination of deposit effect would permit one unit higher compression ratios.

BASED ON PAPER BY **H. J. Gibson, C. A. Hall and D. A. Hirschler,** Ethyl Corp.

INCREASE in antiknock requirement resulting from combustion-chamber deposit accumulation is not a new problem, but it has assumed greater importance as antiknock quality of fuels and antiknock requirements of engines have mounted. Admittedly the requirement increase problem is most severe in vehicles operated in crowded metropolitan areas.

It has been indicated by others that an average value for the increase due to deposits in passenger cars is about 10 octane units in the 80-90 octane number range. If the effects of deposits on requirements could be eliminated, the efficiency of engines could be improved by the benefits from compression ratios approximately one unit higher than they are now.

We have found through experimentation that organic materials originating from both fuel and oil are of major importance in deposit formation. Fuel and oil effects are so interrelated that either variable should be studied only with careful consideration of the effects of the other. Tests with individual leaded hydrocarbons show some differences, but no one type is superior over a wide boiling range. In full-boiling, leaded gasolines covering a wide range in hydrocarbon type proportions, no distinct relationships between hydrocarbon composition and requirement increase have been found. However, with both gasolines and hydrocarbons there is a trend toward smaller requirement increase as fuel endpoint is reduced

The adding of tel to pure hydrocarbons has been found to make requirement increase either larger or smaller depending on the type to which it is added. Lubricating oil can influence effect magnitude. We have also found that the carbon-hydrogen ratio of leaded hydrocarbons can influence the amount and composition of deposit formed. High ratios appear to be favorable.

Tests reveal that removal of heavy ends from lubricating oils tends to lessen requirement increase. The magnitude of the effect depends upon the contribution of the fuel to the organic portion of the deposit. Variations in oil hydrocarbon composition appear less important than changes in oil volatility.

Requirement increase can be reduced by high-output operation during deposit accumulation or following light-duty service. Deposit effects can be reduced by increasing the jacket-coolant temperature, although the net effect is to raise the requirement level. Finally, it was found that combustion-chamber design and deposit location appear to influence requirement increase. A small ratio of combustion-chamber surface area to displacement volume seems to be desirable. (Paper, "Combustion-Chamber Deposition and Knock" was presented at SAE National Fuels and Lubricants Meeting, Tulsa, Nov. 6, 1952. Complete paper will be printed in 1953 SAE Transactions. It is also available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers).

Questions about process control, acceptance sampling, and consumer-vendor relations were answered by this panel of quality control experts: E. L. Fay, Deere & Co.; E. R. Meyer, Eureka Williams Corp.; Secretary I. W. Schoeninger, Globe-Union Inc.; Leader H. A. Weissbrodt, International Harvester Co.; W. H. Smith, Ford Motor Co.; and J. N. Berrettoni, Dr. J. N. Berrettoni & Associates

Statistical Quality Control Makes Tolerances Behave

Irvin W. Schoeninger, Globe-Union Inc.

Report of panel discussion on "Quality Control," held at the SAE National Tractor Meeting, Milwaukee, Sept. 8, 1952.

THE material presented at this session covered the following phases of quality control:

1. Process control.
2. Acceptance sampling and consumer-vendor relations.

Process Control

Question: What are some important techniques of statistical quality control?

Answer: There are four techniques:

1. Frequency distribution—the basis for all control charts—is simply a classification of measurements showing the number of times each measurement of a particular characteristic occurs in a given series of measurements of the same product. Each value may be a measure of size, fraction defective, or number of defects. Since it is usually impossible to wait until enough measurements have been collected for a frequency distribution, control charts are made using small samples which can be collected and measured at regular intervals. For analytical purposes, however, the frequency distribution is a useful statistical tool.

2. Control charts for average $(\overline{X})$ and range (R) are essentially a continuous record of performance with control limits to warn where other than chance variations are occurring. As such, they are powerful instruments for the diagnosis of quality problems and the routine detection of sources of trouble.

The chart for averages is sensitive to changes in process level. When, for example, 2% of the product is out of tolerance, 14% of the averages of four will fall outside of their control limits, giving an increased sensitivity of 7 to 1. An obvious saving in inspection costs can be made by using the control chart for averages instead of evaluating only the individual measurements against specifications.

The chart for ranges tells whether the expected variability is being maintained. A real shift in process variability will be shown by range values exceeding the upper control limit, or by a large number falling below the value for average range, showing an increasing or decreasing variability.

3. Control charts for fraction defective (p charts) and for number defective (np charts) are also useful tools for controlling quality. These are used where limit gages or visual inspection to accept or reject a product may be in use.

The fraction of the product not conforming to the gage or other criteria may be used as the basis for a control chart. For such a chart it is necessary to know the location or level of the process (average fraction defective $\overline{p}$, or average number defective $n\overline{p}$) and the expected spread or dispersion about $\overline{p}$ or $n\overline{p}$. This may readily be computed and, when placed symmetrically above and below $\overline{p}$ or $n\overline{p}$, con-

stitutes the control limits beyond which chance variation will not occur.

p charts are used when the lot size varies, from which the fraction defective is determined. *np* charts are used when the lot or sample size is constant. Each chart is applicable to only one sample size.

4. Control charts for the number of defects per unit (*C* charts) are used where the number of defects in a given unit can be counted but a percentage figure cannot be obtained. For example, there may be eight defects in the final inspection of an automobile, but since the total number possible is large and variable, the per cent cannot be determined. In the use of this type of chart, typical units are (a) a given test size sheet of plastic, (b) a bolt of cloth, (c) a length of wire, and (d) a day's output of a rolling mill.

Here also, control limits may be placed above and below the average value of *C* and serve as a limit for the chance variation of *C*.

Question: What does statistical quality control add to a properly coordinated manufacturing department?

Answer: Statistical quality control promotes good industrial relations because it makes possible higher worker output, resulting in gain to worker and employer. It publicizes good workmanship, which appeals to the pride of the worker.

To secure maximum gain from analytical work, statistical quality control methods must be used. These techniques result in data which are reliable. Often, a study of an apparently successful operation shows defective material being produced. Statistical quality control makes it possible to make decisions with known risks.

Question: How can statistical quality control be sold to the foreman?

Answer: This can be done in several ways:

1. Develop the plan so that the foreman seems to have originated the idea.
2. Show examples of successful applications.
3. Sell the foreman on the fact that the quality control department can render him valuable service.

Question: What can be done to bring the quality control department and product engineering closer together?

Answer: Most frequently, tolerances are a source of friction between these groups. Both must realize that the ultimate goal of each is a satisfied customer and develop a mutual respect for the abilities of each. Basically, the quality control department determines machine and process capabilities that provide the product engineer with very necessary information.

Many times, it is necessary to control a machine within close tolerances in order to avoid expensive rework operations. However, close tolerances need to be evaluated in terms of cost and machine capability. Often, a compromise results between what is wanted and what can be produced.

Of particular interest to the product engineer is a new approach to the problem of additive tolerances and mating parts. If parts are produced from a machine operating in statistical control, and if dimensions are independent, then the tolerance of an assembly of such parts is expressed $T(\text{total}) = \sqrt{T_1^2 + T_2^2 + T_3^2 \ldots\ldots T_n^2}$. This will obviously result in smaller assembly tolerances than the conventional $T(\text{total}) = T_1 + T_2 + T_3 \ldots\ldots T_n$.

Taking advantage of this, the product engineer may allow wider tolerances on individual parts without adversely affecting the desired assembly tolerance.

References may be found in most books on statistical quality control and in the magazine *Industrial Quality Control* published by the American Society for Quality Control, as follows:

"Engineered Assembly Tolerances," September, 1947.

"Tolerances, Additive or Pythagorean," November, 1948.

"Some Statistical Principles of Tolerances," May, 1950.

Question: How are print tolerance changes made?

Answer: This is done as follows:

1. Machine capabilities are analyzed and the natural variation compared with print tolerances.
2. Print tolerances are analyzed from the design viewpoint, using the statistical method of adding tolerances, if applicable.
3. An acceptable quality level per cent defective is adopted.
4. The cost of producing to the tolerance at the desired acceptance quality level is determined.
5. A decision is made to pay for the added cost or to open print tolerances to machine capabilities.

Question: How are reduced tolerances using the sum-of-squares method put into practice?

Answer: A liaison engineer, thoroughly versed in the theory and practice of statistical quality control, with power to act, should be delegated the responsibility of securing agreement of product engineering and to ensure that parts are produced under controlled conditions.

Question: How can short-run jobs be controlled?

Answer: They can be controlled in several ways:

1. Control charts can be set up in the usual way, with samples being taken irrespective of the time element.
2. Charts are filed and used when the jobs are run.
3. Machine capabilities are determined and serve as a basis for setting up additional charts.
4. In punch-press operations, the control chart stays with the die. If the chart shows a need for die rework, the job is done before the die is next scheduled.

Question: How can sampling by attributes be applied to automatic machining operations?

Answer: This can be done as follows:

1. A larger sample size is required when sampling by attributes to furnish the same degree of protection as when variables are used. A sample of 14 by attributes is equivalent to a sample of five by variables. Other ratios are 50 to 9, 95 to 16, and 175 to 25.
2. Sometimes "tighter than spec" limits are used to produce a predetermined fraction defective of possibly 10–15%. A sample of 10–20 will then produce, on the average, 1–2 defective units per sample, which can be charted and kept in control. Out-of-control points will then indicate pieces being made out of the real spec limits.
3. If attributes are used, a frequency distribution of at least 50 measurements should be made as an initial study of the operation.

Question: What about the display of control charts showing individual performance as compared to group performance?

Answer: If individuals seem to work on a comparable basis, then a group chart should be sufficient. However, individual control charts will show up suspected poor workmanship. In order to avoid embarassing situations as, for example, where a stewardess is the offender, such a chart can be kept semiprivate in the foreman's office.

Question: What strides have been made in applying statistical quality control to foundry operations?

Answer: Control charts have been used on:

1. Moisture content of sand.
2. Temperature and consistency of pour.
3. Performance of each molder.

Question: What is Ford Motor Co. doing with statistical quality control on the assembly line?

Answer: The most important facts are presented on a simple chart, which can be understood at a glance by the people responsible for taking action. The quality of the overall assembly is shown as well as the individual defects, which lower the quality. The following information is shown at hourly intervals throughout the day:

1. Per cent of total production that is O.K.
2. Average number of defects per assembly.
3. Individual chronic defects and the per cent of each type of chronic defect to total production.

Another automotive manufacturer has a chart at the end of the assembly line that shows the number of defects per truck, classified as follows:

1. Due to purchased parts.
2. Due to parts manufactured within the organization.
3. Defects per truck remaining after repair.

Acceptance Sampling and Consumer-Vendor Relations

Question: How can differences between consumer and vendor be resolved?

Answer: Both must understand what is wanted and how the quality shall be judged. This involves a mutual understanding of what dimensions shall be gaged, how they shall be gaged, which are most important, and what quality is wanted.

Question: Is there any legal basis for the return of defective material?

Answer: The purchase contract usually contains the quality level agreed upon and thus becomes the basis for acceptance of material. When material that has been found acceptable for a considerable period of time is suddenly rejected, then this is probably what has happened in the purchaser's organization:

1. A quality control department has been established.
2. The inspection personnel, which had previously used their own judgment and accepted questionable material, has now been given standards by which considerable defective material is found.

The vendor has not been notified of the change in policy and continues to manufacture on what was thought to be a satisfactory basis.

3. New levels of quality have been set.

In such cases it is wise to proceed slowly, to determine the quality level which has been found acceptable, to use this as a basis for establishing the new acceptable quality level, and to notify the vendor of any change which will require an improvement in his manufacturing process.

Question: How can specifications for castings best be made?

Answer: The best result is obtained by a consumer-vendor conference. In this way both the needs of the consumer and the problems of the vendor can be considered to arrive at a mutually satisfactory specification. Defects, such as shift in pattern, fins, and burrs, must be defined and an acceptable quality level agreed upon. Often, the consumer needs guidance in arriving at practical quality levels.

Question: Should dimensions be specified according to relative importance as critical, major, minor, and incidental?

Answer: Many companies are today classifying dimensions into the classes stated and specifying the acceptable quality level for each class. A supplier should insist on a classification of defects or dimensions and the acceptance quality level for each.

Question: How are parts inspected for critical and minor defects for Army Ordnance?

Answer: Select the proper sample for the size of

the lot to be inspected, and use the appropriate acceptance numbers for the quality levels specified for the major and minor defects.

Question: How can large shipments of packaged powdered material be sampled and tested?

Answer: The analysis of variance method offers the solution to the testing of such a shipment. The packages are divided into five large groups and from each group, five packages—or 25 in all—are taken, each identified as to the group and the position in the group.

The variation of test results within each group is compared to the variation between groups using statistical analysis, the result of which will determine, with a known risk, the homogeneity of the shipment.

Question: How is it possible to sample for quality assurance by destructive testing?

Answer: This can be done in several ways, for instance:

1. One automotive manufacturer destructively tests one major body assembly per hour from each line.
2. Test specimens may be used for testing the quality of a welding operation.
3. Nondestructive tests may be correlated with destructive tests, such as Rockwell hardness and tensile strength.

Supercharger Selection . . .

. . . for a particular line of engines is aided by knowledge of engine characteristics as a second-stage compressor.

BASED ON PAPER BY **Lloyd Johnson** Caterpillar Tractor Co.

ENGINE manufacturers publish performance curves of production model diesels, but many decisions are needed in choosing type and size of supercharger, drive means, peak supercharging pressures, and size and effectiveness of intercoolers, if any. Testing a typical model to determine response to variation in intake and exhaust conditions will assist in evaluating engine potentials with any system of supercharging. (Paper, "Supercharged Diesel Performance versus Intake and Exhaust Conditions," was presented at SAE Annual Meeting, Detroit, Jan. 16, 1952. It will appear in full in the 1953 SAE Transactions. It is also available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers).

Results in Test for Supercharger Selection

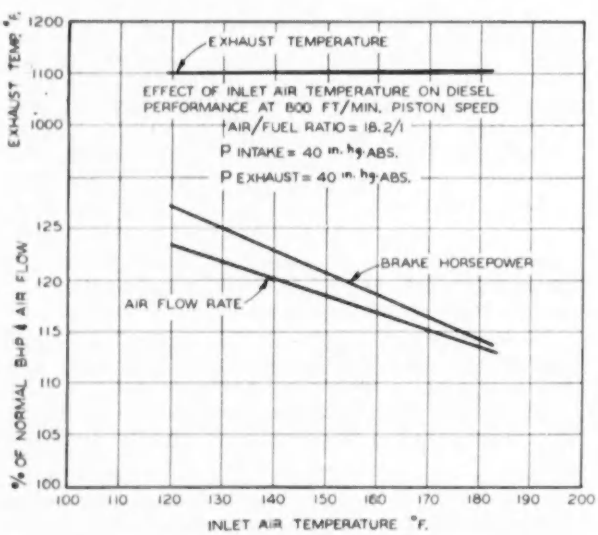


Fig. 1—Effect of inlet air temperature. Exhaust temperature remains practically constant while bhp changes as direct function of airflow. Similar characteristics are found at higher piston speeds

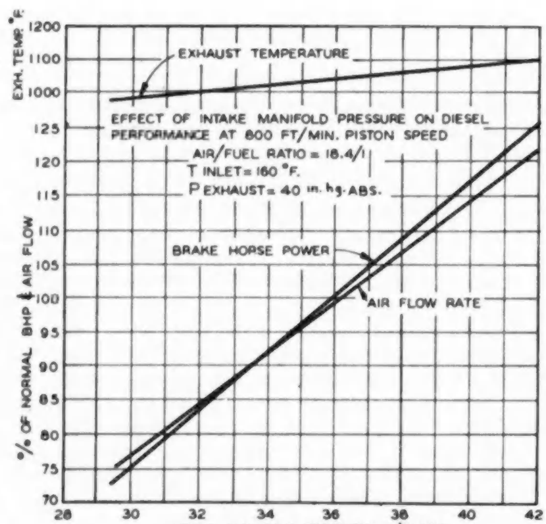


Fig. 2—Effect of intake manifold pressure. Note increasing airflow, bhp, and slight increase in exhaust temperature, which are typical of increased boost

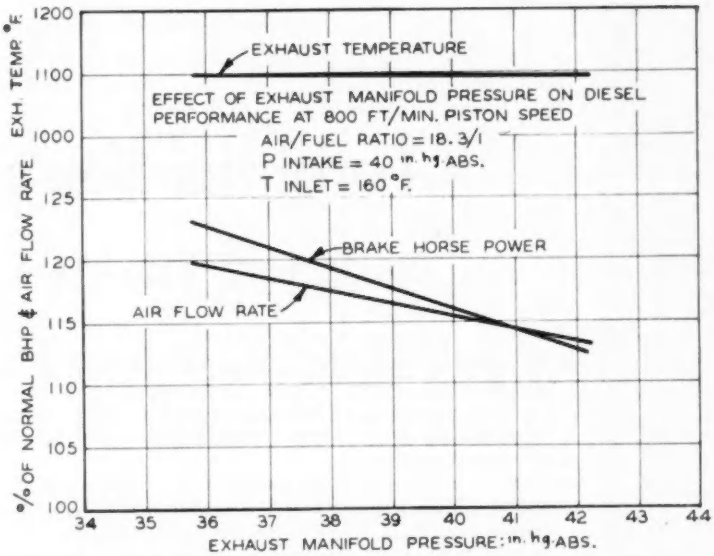


Fig. 3—Effect of exhaust manifold pressure. Exhaust temperature remains unchanged, for a given speed and air/fuel ratio, while increasing back pressure restricts airflow and causes a drop in bhp

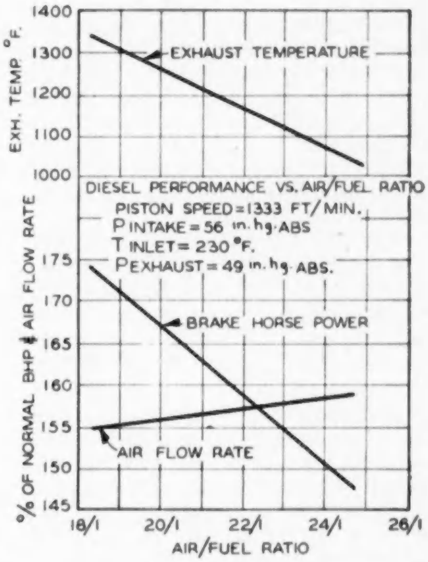


Fig. 4—Effect of air/fuel ratio on airflow, bhp, and exhaust temperature. Increase in airflow with reduction in fuel flow rate can probably be attributed to reduction in temperature of residual gases and of combustion-chamber and cylinder-wall surfaces

Military Aircraft . . .

. . . need reliability more than simplicity. Complexity grows out of demands imposed on craft and pilot. In Korea, with complex aircraft, we are scoring 16 to 1, indicating effective balance between performance, equipment and armament.

BASED ON PAPER BY **Col. H. J. Sands,** Air Research and Development Command, U.S. Air Force

THE demand to make our military aircraft simpler is a mounting cry in which even some of our top-notch pilots join, but most of the complexity arises from the increased demands placed on pilots and aircraft by high speed and high altitude.

We have automatic heat controls and automatic oxygen regulators. Do we want pilots fooling with controls to keep fingers from freezing or trying to regulate oxygen supply while engaged in supersonic battle? It requires much skill to start a turbojet engine properly every time. Even with skill we get "hot" starts and "false" starts. Therefore, it seems desirable to have an engine control to eliminate the human element. It also seems necessary to have controls for maintenance of constant and maximum rpm and temperature in the engine to relieve the pilot of highly complicated computation problems and detailed understanding required for proper engine operation.

Complexity of fire control is also criticized, but no human being has the sensory capability to measure target speeds, ranges, angles, and other ballistics necessary to get him on the target under present high-speed conditions. Both powerplant and fire control systems are complex, but they make the difference between a superior and an average or inferior weapon. A technically superior item usually means complexity, and increasing efficiency generally means increasing complexity. That complex aircraft pay off is attested by the 15 or 16 to 1 ratio in Korean battles. It is due, I believe, to the balance and versatility of our aircraft and the superiority of our crews.

While we should complain about complexity, guard against undue complexity, and publish articles about it, our prime mission should be reliability. The complexity of an item is of little matter as long as it does not stand in the way of reliability and dependability, and as long as weight and bulk do not prevent carrying the item.

Civilian concerns can make an invaluable contribution by building in reliability during the design and development stage and by testing and re-testing equipment before putting it on the market. It is also vital that production departments pay close attention to quality control. This has been one of our greatest problems. (Paper, "New Design Requirements Learned from Korean War Aircraft," was presented at SAE Metropolitan Section, New York, Nov. 13, 1952. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers).

Turbines Seek

PRIMARY source of power in the large majority of helicopters today is the reciprocating engine, but the gas turbine is coming up fast. Even in its present state of development, the turbine is superior in some ways to its piston-equipped relative. And it can handle some helicopter missions as well if not better. But continuing improvements in specific weight and fuel consumption will enable turbines to handle these jobs even better . . . and take on new ones as well.

What advantages do turbines offer as powerplants for rotary-wing aircraft? For what missions are they suited? Not suited? How do turbines need to be improved? Here's how we see the situation . . .

"Free" Turbines Have Inside Track

Turbines have a lot to recommend them as powerplants for helicopters—and many of these benefits hinge on using 2-shaft turbines. Since this is true, it might be best to first explain what is meant by a 2-shaft or mechanically free turbine.

Fig. 1 shows a schematic drawing of one. As can be seen, it consists of two basic units which are physically separated from each other. The gas producer section on the left includes the compressor, compressor-drive turbine, combustion chambers, and accessories. The power output section on the right includes the power turbine, reduction gear, and the power output shaft. Thus, the basic difference between this 2-shaft job and a single-shaft "solid" turbine is that output shaft speed is independent of the speed of the gas-producer shaft.

Advantages Turbines Offer

Now, keeping this fact in mind, let's take a look at some of the advantages to be gained by using 2-shaft turbines as helicopter powerplants.

- Less power required to start, especially under cold weather conditions. Only the compressor and its turbine are rotated in the starting cycle, thus eliminating drag of the power turbine and main reduction gear.
- Torque increases with decreasing power turbine speed. (See Fig. 2.) When there is a speed decrease resulting from a sudden load, this characteristic will give faster speed recovery. Engine power remains approximately constant from 80 to 100% power turbine speed, thus allowing wider operating range without loss of power.
- Great flexibility of operation because the power turbine can operate over a range of loads and speeds without changing the gas-producer turbine operating point. The control system is markedly simplified, therefore, because the governor on the gas producer need only meter fuel to maintain a constant speed.
- Oil consumption is extremely low.
- Warmup periods are short. Actually little or no warmup is required since it is not necessary to warm large quantities of oil before taking off.

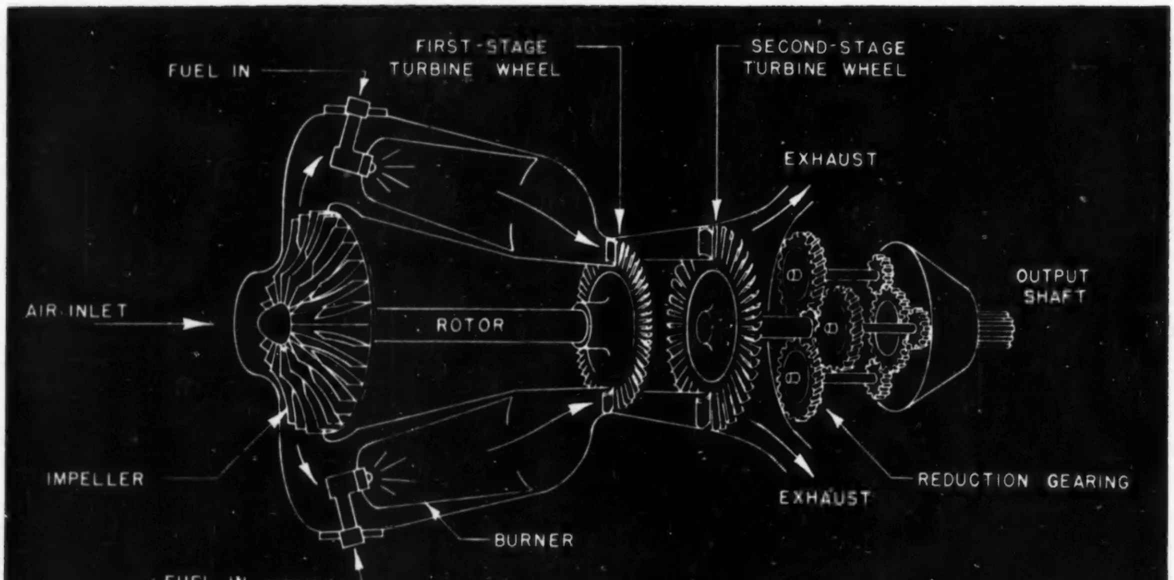


Fig. 1—A two-shaft gas turbine is said to have much to offer the helicopter designer in his search for a better powerplant. Many of its advantages stem from the fact that there is no physical connection between the power output section (on the right) and the gas-producer section (on the left)

To Dethrone Piston Engines From 'Copter Realm

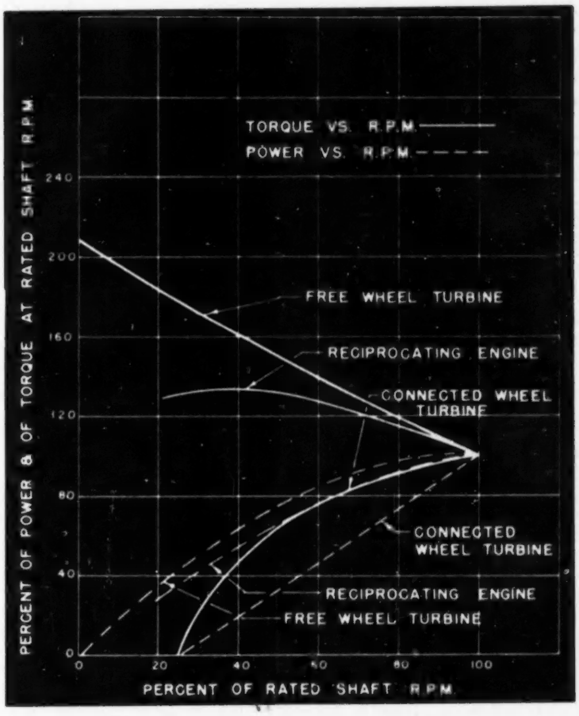


Fig. 2—With a free wheel or 2-shaft turbine, torque increases with decreasing power turbine speed, and engine power remains approximately constant from 80 to 100% power turbine speed. Note the difference between these characteristics and those of piston engines and single-shaft turbines

- Greater crew comfort through reduction of noise level and elimination of engine vibration.
- Ability to burn cheaper, less inflammable grades of fuel. This not only simplifies logistics and reduces fire hazard, but it also compensates somewhat for high fuel consumption of turbines.
- Less aerodynamic drag—minimum fuselage size is often dictated by engine width and the small cross-section of turbines means less drag in forward flight. This also helps to compensate for higher specific fuel consumption.

Turbines Weigh Less . . .

The thing that really makes turbines inviting as helicopter powerplants, however, is their low specific weight. For example, turbines of less than 1000 hp weigh an average of only 40% that of piston engines; turbines between 1000 and 2500 hp average 56%; and turbines over 2500 hp average 63% the weight of piston jobs. (See Fig. 3.) What's more, further reductions in installed weight are possible by elimination of clutch, cooling fan, and special cowling necessary for piston engines.

. . . But Gulp More Fuel

Unfortunately, however, the weight saved by using turbines is not all gain. Higher fuel consumption of gas turbines requires that more fuel be carried for equal range or endurance. Thus, there are break-even points at which the additional weight of fuel required equal the weight saving of the turbine engine. For example, the break-even point for hovering is about 4 hr. (See Fig. 4.) At all lesser durations, there is increasing payload advantage in the turbine-equipped helicopter.

Therefore, whether turbines are selected for various helicopter applications depends a great deal on their fuel consumption characteristics. If missions call for operation at power approaching maximum continuous rating then turbines are a likely choice. That's because their specific fuel consumption is a minimum at full power, whereas piston engines operate most economically at part load. (See Fig. 5.) Where missions require cruising at minimum power or place emphasis on endurance time rather than

Based on papers:

Characteristics of the Two-Shaft Gas Turbine in Helicopters
by W. B. Anderson
Boeing Airplane Co.

The Selection and Evaluation of Powerplants for Helicopters
by E. F. Katzenberger and H. Nozick
Sikorsky Aircraft Division, United Aircraft Corp.

Design Considerations for a Helicopter Gas Turbine Powerplant
by J. L. Koetting and L. R. Wosika
Solar Aircraft Co.

Matching the Characteristics of Helicopters and Shaft Turbines
by D. N. Meyers and Z. M. Ciolkosz
Piasecki Helicopter Corp.

These papers were presented at SAE Annual Meeting, Detroit, Jan. 14, 1953.

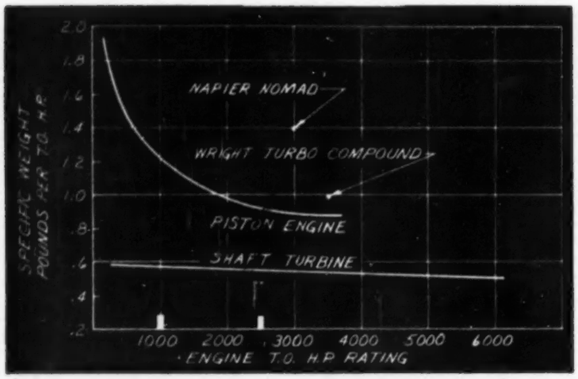


Fig. 3—Horsepower for horsepower, turbines weigh less than reciprocating engines. Turbines of less than 1000 hp weigh an average of only 40% that of piston jobs; turbines between 1000 and 2500 hp average 56%; and turbines over 2500 hp average 63% the weight of piston engines

range, poor part-load fuel economy of turbines weighs heavily against their selection.

Missions for which Turbines Are Now Suited . . .

To be more specific, here are the helicopter applications for which turbines are now suited:

1. Transport operation for ranges up to about 200 miles . . . with the strong possibility of increasing this competitive range to about 350 miles in the near future.
2. "Crane" or short ferry missions in which most of the time is spent in hovering or extremely slow forward speeds when power required is high.
3. Operation in low temperature areas. Since temperature at the compressor inlet is reduced, both thermal efficiency and net power output are increased.
4. Missions which must be flown at high cruising speeds, such as urgent rescue missions.
5. Transportation of freight or passengers between points a short distance apart, but at greatly different elevations, where most of the cruise time is spent in climbing.

. . . Not Suited

And here are the helicopter applications for which turbines are not now suited:

1. Cruise at minimum power.
2. Missions which place emphasis on endurance time rather than range.
3. When speed is limited by aerodynamic considerations, such as stall or compressibility, to a value well below the speed which otherwise could be obtained by the power available.
4. Missions which require most of the flight in high-temperature areas.
5. Missions where freight or equipment is carried outside the fuselage for long distances. Parasite drag is much more serious for a turbine-equipped helicopter since it normally flys at high speeds.

Many Roads Lead Way to More Missions

Much can be done, however, to overcome the part-load operation deficiency of turbines.

One possible solution would be to use two or more small turbines instead of one large one. In this way, one engine can be shut down and the other operated economically at or near maximum continuous power. The fact that a turbine can be made to deliver full power in 30 sec after a cold start makes this possible. If a twin-turbine helicopter operating on one turbine should experience powerplant failure, the reserve engine can be operating by the time the helicopter has lost 800 ft of altitude.

Still another approach would be to design the helicopter so that it could fly at a speed fast enough to absorb the full installed horsepower. In general, today's helicopters which have sufficient power for good hovering performance are unable to use this power in forward flight. Maximum velocity is usually limited by aerodynamic considerations rather than by power. The usual limit is tip stall of the retreating blade. Any attempt to fly faster than this limit results in extreme vibration even though the power required may be well below the available horsepower.

A third possible method of attack would be to design compressor and turbine for peak efficiency at part load so that specific fuel consumption would be improved—even at the expense of decreased efficiency at take-off power. Question is, is this possible?

When it comes right down to it, every improvement which decreases specific fuel consumption will enable turbines to handle present helicopter missions better . . . and take on new ones as well. A logical question then is: What is being done to reduce specific fuel consumption and increase specific output (hp/lb of weight) of gas turbines? The answer is that work on both fronts is being conducted continuously and information coming from the engine industry is most encouraging.

Specifically, this progress is associated with mechanical and metallurgical advancements.

Improvements of a mechanical nature are concerned chiefly with efficiency of the compressor and the turbine. Although compressor and turbine efficiencies above 85% are already attainable, even small improvements will boost overall thermal efficiency and net power output a lot. Approximately

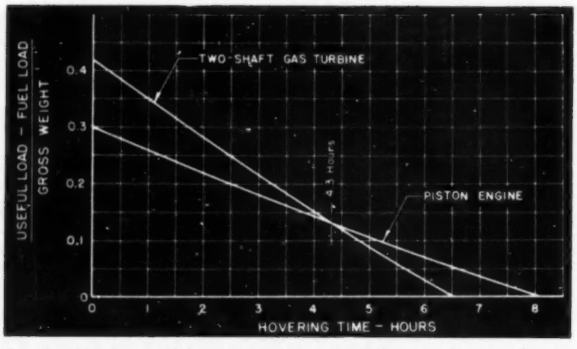


Fig. 4—Weight saved by using turbines in helicopters is not all gain. There are break-even points for various types of missions at which additional weight of fuel required equals weight saved by using the engine. As shown above, the break-even point for hovering is about 4 hr. At all lesser durations there is increasing payload advantage in the turbine-equipped helicopter

two-thirds of the power developed by the turbine is used to drive the compressor, and only one-third is available for useful work. For the same fuel consumption, therefore, a 2% improvement in turbine efficiency increases net output by 6%, and a 2% improvement in compressor efficiency increases net output by 4%.

Metallurgical advances involve ability to use high turbine inlet temperatures through use of improved alloys. Higher turbine inlet temperatures mean better thermal efficiency and greater net output which, in turn, have an important bearing on size, weight, and specific fuel consumption of a turbine.

On the other hand, to take full advantage of any increase in turbine inlet temperature, higher pressure ratios should be used. And these tend to make the compressor longer and heavier. Considerable improvement is being made in this field, however. Increases in pressure ratio per stage are making possible:

1. Higher overall pressure ratio without extending engine length.
2. Fewer stages for a given pressure ratio—hence, decreased weight.
3. Alleviating the complexity of multistage design.

Actually, so many variables are involved it is difficult to predict improvement trends in turbine performance. However, reduction in specific weight will probably progress more rapidly than reduction in specific fuel consumption.

(Papers on which this abridgment is based are available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

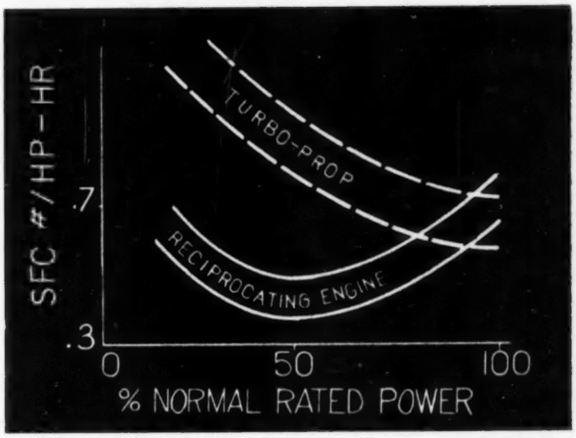


Fig. 5—Whether turbines are selected for various helicopter applications depends a lot on their fuel consumption characteristics. If missions call for operation at power approaching maximum continuous rating then turbines are a likely choice. That's because their specific fuel consumption is a minimum at full power

Based on Discussion

Question: What are the relative costs of turbine and reciprocating engines?

Answer: Studies indicate that turbines can be made for less. This is attributable to their simplicity and small number of parts. It appears that when manufacturing and metallurgical problems can be made compatible, cost of turbines can be substantially reduced.

Question: Right now the period between overhauls of turbine engines is 300 hr. What improvement can we expect in future years?

Answer: It may be possible to get 100 to 150 hr more in a year or so. Actually it's difficult to predict what improvement can be made, but the aforementioned figures do not seem unattainable.

Question: Why is there a need for overrunning clutches with split turbines?

Answer: A good engine should not have to pull the drag of an engine that has failed.

Question: Could you do the same thing with an air shutter?

Answer: Yes, and it may be desirable.

Question: Do all multi-turbine engine installations deliver power to one shaft?

Answer: No. Installations have been made where engine power is delivered to separate gear boxes at the rotor. A shaft interconnecting both rotors is also used to transmit power from one engine to both rotors.

Question: Would Mr. Meyers care to discuss the combination of the turbine reduction gear with the rotor transmission?

Answer: From the helicopter designer's standpoint, a combination should be used that will result in the lightest installation. For example, a lighter installation is obtained by using two high-speed gears rather than two low-speed ones. Reduction should be divorced from the engines. This provides flexibility so that engines can be used in different helicopter configurations.

Question: Has water-alcohol augmentation been considered to provide the difference between normal maximum power and available maximum power, that is, the 20% extra power occasionally needed?

Answer: Water-alcohol augmentation does have advantages, but it requires extra gimmicks. Limitations of weight, plus the fact that large quantities of water are required, make it impractical.

Igor B. Bensen,
Kaman Aircraft Corp.

Our experience with a turbine-powered helicopter indicates that noise level is far lower than that of a piston engine installation.

To be sure, the absence of vibration in the airframe greatly enhances the comfort of passengers, but the absence of engine noise is startling to unprepared observers.

Elastomers

ELASTOMERS are rubberlike materials with a variation of consistency from almost fluid to a modulus of elasticity of about 10,000 psi. Most usable compounds have a modulus from 100 to 500 psi. They are especially characterized by their ability to resist deformation and, when deformed, to return to their original shape quickly upon release of the deforming force. They are generally tough, with good tear and abrasion resistance, although not all of them exhibit these attributes. They are polymers or molecular chains, produced by organic chemistry either in the chemical growth reactions of trees, shrubs, or herbaceous plants, or in the polymerization vats of our large synthetic rubber factories. An exception to this concept of organic composition is the group of silicone rubbers, which are classed as semi-organic because of the partial replacement of carbon by silicon in the elastomeric molecule.

The original elastomer is the well-known natural rubber, a product of the rubber tree. It is to this product that the word "rubber" should be confined in its strictest sense. Natural rubber can be made from the coagulated juices of many plants such as the dandelion, guayule, and other milky-juiced types. Nature, as well as man, has a hard time defining elastomers, and some of the milky juices contain such high percentages of resins that their products are more plastic than elastic.

The use of natural rubber had so expanded by the first decade of this century that it had become one of our essential materials. Our mechanized civilization has become so dependent upon it and other elastomers that our vehicles cannot roll and our engines cannot produce power without them.

These materials account for about 7% of the dry weight of a modern interceptor and about 10% of the dry weight of a large bomber.

In the early 1900's several countries recognized the importance of rubber and embarked upon research programs to free themselves from dependence on the rubber tree and the cartel. The result was Buna-S, developed in Germany and chloroprene (DuPont's Neoprene), developed in this country. Many other synthetics followed quickly and new ones are being developed each year.

Let us look at the serviceability of some of the elastomers that are being used today. Table 1 compares these elastomers and rates them on their physical properties.

Weather-Resistant Types

At the present there is a lot not known about the exact nature of the weathering or aging action. It is most generally accepted that the combined effect of heat, light, oxygen, and ozone produces an oxidation in the surface of the part. This oxidation lowers the tensile strength and affects the molecular bond that gives the elastomer its elastic properties. Should the part be under tension, the oxidation is more rapid, and some natural rubber compounds have shown cracks in as short a time as seven days. The shield on a small light made from a natural-butadiene-styrene blend has cracked in three days, while in an inside office.

Weather cracks appear as a reticulated network, which progress to large cracks by coalescence. Under tension the cracks usually appear parallel to one another, and at right angles to the direction of the load. Under tension these cracks join longitudinally and finally failure occurs in the form of a jagged tear. The small adjacent cracks can easily be seen by stretching the material next to the break. On parts of varying thickness the cracks will always appear at the thinnest spot, which is the point of greatest deflection and highest tension.

To combat the occurrence of weather cracking the designer can choose a compound from several weather-resistant groups of materials. Probably the most widely used group are the chloroprenes, more commonly known by their trade name Neoprene. This group of compounds is made from basic polymers that are inherently resistant to oxidation and that do not use sulfur as vulcanizing agents.

Polysulfide compounds (Thiokol) exhibit excellent weather resistance. These compounds have lower mechanical properties and are, therefore, not generally used for mechanical goods except as thin gaskets or coatings. They are often used as sealing putties.

Butyl rubber, a copolymer of isobutylene and isoprene, is almost impervious to the passage of air and is quite generally used for inner tubes. Resistance to tearing is good but resilience is poor, so that the compounds are subject to cold flow. This group of compounds exhibits, in addition to good weather resistance, excellent resistance to deterioration from the newly developed synthetic lubricants and hydraulic fluids.

The elastomers most highly resistant to oxidation or weather cracking are the group known as silicone rubbers. They are compounded from organosilicon-oxide polymers and are generally not affected by ozone or rays from the sun. Tensile strength and tear resistance of this group are generally low, and care must be taken in designing for the use of these compounds. Great improvements have been made in these properties, and these recent developments in the silicones have produced

Are Popular for Aircraft

Charles M. Miller, Materials Engineer, Northrop Aircraft, Inc.

Excerpts from paper, "Elastomers—Rubberlike Materials," presented at the SAE National Aeronautic Meeting, Los Angeles, Oct. 2, 1952.

Table 1—Physical Properties of Typical Rubber Compounds

	Natural Rubber	Reclaim Rubber	GR-S	Buna N	Neoprene	Butyl	Thiokol	Silicone
Derived from	Tree (Hevea)		Butadiene and styrene	Butadiene and acri-lonitrile	Chloroprene	Iso-butylene	Poly-sulfide	Silicone
Tradenames	———	———	GR-S, Hycar OS, Buna S	Hycar OR, Perbunan, Butaprene, Chemigum	GR-M, Neoprene	GR-I, Flexon	GR-P, Thiokol	Silicone, Silastic
Weight, lb per cu in.	0.0335	0.036–0.057	0.0338	0.036	0.045	0.0328	0.048–0.057	0.058–0.076
Resiliency	Excellent	Fair	Fair	Fair	Very good	Fair	Poor	Poor to very good
Tensile Strength	Excellent	Fair	Fair to good	Good	Very good	Good	Poor	Poor to fair
Water Imper-meability	Excellent	Good	Good	Good	Fair	Very good	Very good	Good
Gas Imper-meability	Good	Fair	Good	Good	Very good	Excellent	Excellent	Good
Flexure Life	Excellent	Fair	Good	Good	Very good	Very good	Poor	Poor to very good
Abrasion	Excellent	Fair	Excellent	Excellent	Excellent	Good	Poor	Poor to excellent
Tear Resistance	Very good	Fair	Fair	Fair	Good	Good	Poor	Poor to good
Heat Resistance	Fair	Fair	Fair	Good	Good	Good	Poor	Excellent
Cold Resistance	Very good	Fair	Very good	Fair to good	Fair to good	Good	Fair to good	Excellent
Cold Flow	Very good	Good	Very good	Very good	Fair	Fair	Poor	Poor to excellent
Natural Aging	Fair	Fair	Good	Good	Excellent	Excellent	Excellent	Excellent
Ozone	Poor	Poor	Poor	Poor	Excellent	Excellent	Excellent	Excellent
Light	Fair	Fair	Fair	Fair	Excellent	Excellent	Excellent	Excellent
Petroleum Oils	Poor	Poor	Poor	Excellent	Good	Poor	Excellent	Good
Aromatic Fuel	Poor	Poor	Poor	Good	Poor	Poor	Excellent	Poor
Non-Aromatic Fuel	Poor	Poor	Poor	Very good	Fair	Poor	Excellent	Poor

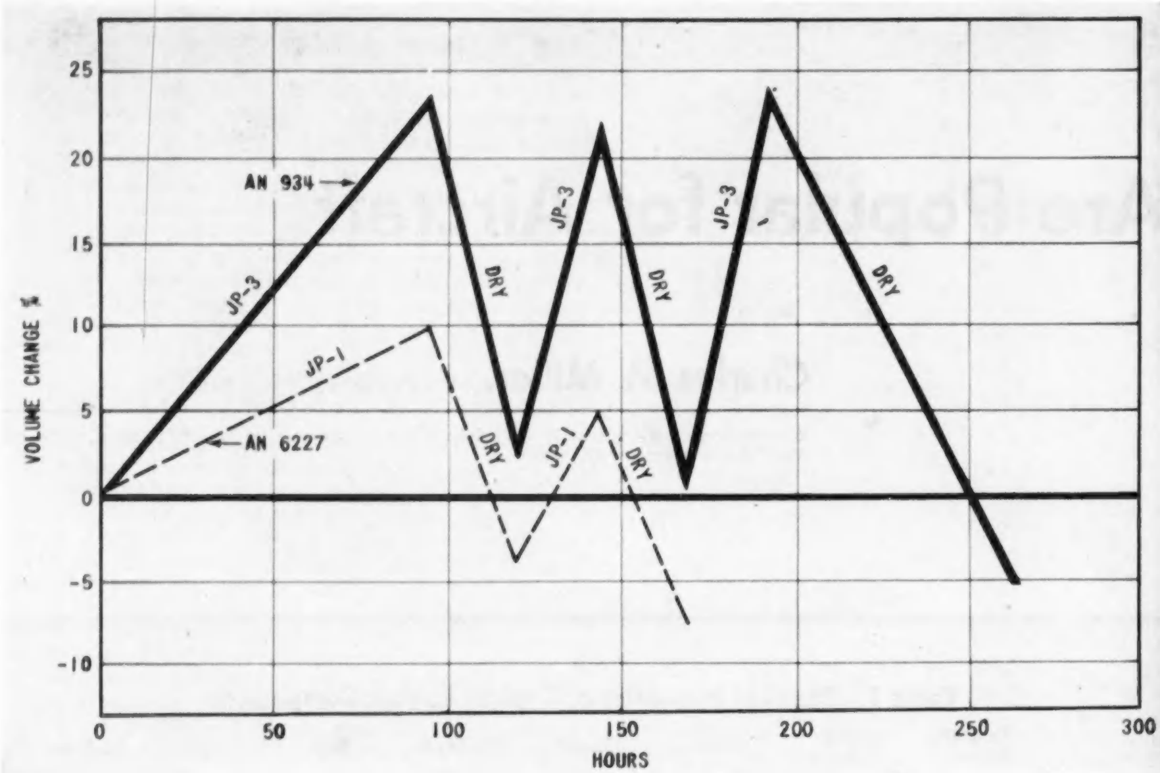


Fig. 1—Swell-shrink characteristics of fuel-resistant o-rings

compounds more nearly approximating the "universal compound" than any other known elastomer.

Fuel- and Oil-Resistant Types

The elastomers possessing the best resistance to petroleum-base products, such as fuel and oil, are the nitrile or butadiene-acrylonitrile compounds. This group cannot be softened by adjustments in the polymer as can the other synthetic rubbers, and must rely solely upon plasticizers to achieve softness. These chemical additions to soften the polymer are generally soluble in fuel, especially the aromatic types. As a result, the fuel replaces the plasticizer, swells the compound 10–30%, and acts as the plasticizer in producing a softening of the compound. Upon drying, the fuel constituent that is in the compound dries out and the part shrinks, often to less than its original size. Upon rewetting, as in refilling a dry fuel tank, the seals may have shrunk sufficiently so that leaks occur until the compounds are replasticized by the fuel and again swell to fill their cavity. (See Fig. 1.)

The careful selection of basic polymer, with just the right amount of butadiene and acrylonitrile and the correct plasticizers and fillers, has produced an excellent group of fuel-resistant compounds that are now in use.

These nitrile compounds do not have very good weather resistance. For this reason there is an extensive program, in the early stages of establishment, to date-stamp all such parts to be sure that old parts will not be the source of failure. If these parts are replaced at periodic overhaul before they give trouble, fuel systems failures from this source should be cut down. This is an ambitious program, and will take many months to become common practice.

For incidental spillage of fuel or oil the chloroprene group is quite satisfactory. Here there is a combination of factors that usually applies. Such applications are generally also subject to weathering, and a decision must be made as to which would be the most damaging, the fuel or the oil, should it get on the seal, or the oxidation to which the seal would be subjected all the time.

Silicone rubber o-ring seals are used on diesel engines, the only elastomer capable of resisting deterioration by both the temperature and the oil. At temperatures of 200 to 400 F these are the only elastomers that will be serviceable as oil valve seats and diaphragms.

Hydraulic-Fluid-Resistant Types

The hydraulic fluid most commonly used in the aviation industry is the red petroleum-base oil. This low-aniline-point fluid causes high swell of almost all elastomers, the most resistant of which are the Thiokols. This elastomer group has lower mechanical properties and is not used for mechanical goods except as flat gasketing or in coatings.

Nitrile is the next best polymer, and is most widely used for seals and diaphragms. These com-

pounds are quite similar to the lubricating-oil-resistant stocks. While chloroprene and silicone compounds are fairly resistant to lubricating oil, they are swelled to excess by the red petroleum-base hydraulic fluid.

Here again, as with fuel immersion, even the best nitrile compounds undergo a progressive shrinkage on successive wetting and drying, although the action is not as severe as with the aromatic fuels.

The use of the new low-flammability hydraulic fluids such as AMS 3150 has required the development of a new series of compounds, as the nitrile and other oil-resistant types are excessively swelled and softened by the phosphate ester fluids. Butyl rubber has proved to be the most swell resistant of the polymers available at this time. Here a compound with good tear resistance and low compression set is used to make the seals in these hydraulic systems. The designs of the packing glands and o-ring grooves must be carefully worked out to allow for the shortcomings of the sealing material. Care must be taken to prevent the contamination of the hydraulic fluid with petroleum-base oils, as these packings may swell from 50 to 250% on immersion in petroleum fluids of low aniline point.

With these new fluids, we see parallel developments going on: new fluids, new sealing or packing materials, and new design criteria to handle both.

High-Temperature-Resistant Types

All of these elastomers are vulcanized, or oxidized as in the silicones, at high temperature, which is often referred to as the "cure." Exposure to higher temperature further "cures" the compound. Otherwise, degradation due to chemical breakdown may occur.

The best high-temperature-resistant elastomers are the silicone rubbers. They are usable under continuous service to 400 F or more, depending on the application. The next best group are the nitrile compounds. These, however, will harden and lose their elasticity, along with a reduction in tensile strength, if subjected to heating at temperatures exceeding 250 F. On a comparative test for 100 hr of intermittent heating to 250 F for one to two hours at each cycle, the nitrile compound suffered over 50% reduction in tensile strength and elongation, while the silicone compounds did not lose in either of these properties. Chloroprene compounds are also used for high-temperature service, but are generally not as good as the nitrile elastomers.

Here again we must look at the conditions of exposure. The exposure of the compound to an atmosphere containing free oxygen will produce an embrittling glaze on the surface of some nitrile compounds, which surface crust will break readily. Some cracks may appear without flexing the part, and may be caused by surface shrinkage. Should this same compound be protected from the air, as between flanges, the surface will not be so glazed and will remain rubbery in texture.

In applications requiring heat-resistant compounds the designer is going to have to use more ingenuity in design, to place his seal in the coolest location and possibly provide cooling mechanisms such as radiation shields or vanes. The temperatures that we have to work with have gone up steadily in the last few years. We are now at the point where even the very best temperature-resistant elastomers are marginal, and we can see the future where the compounds used today will be wholly inadequate.

Low-Temperature-Resistant Types

The elastomers exhibiting the best flexibility at low temperature are the silicone rubbers. Some of these compounds are almost as flexible at -65 F as they are at room temperature. The silicone stocks compounded for low compression set, however, are not as flexible at -65 F, and the designer must again compromise.

Natural rubber and several of the synthetic rubbers can be compounded to give excellent low-temperature service. Here compromises are again required. To get the best toughness, a natural rubber stock will probably be selected and weather, oil, and fuel resistance will immediately be compromised. A coating of thin chloroprene could be applied to tubular parts, which would increase resistance to weathering and damage from spilled engine oil. A second coating, usually a silicone grease, may be required to keep the first coating from sticking to metal surfaces. Hydraulic oil or fuel will quickly delaminate the chloroprene coating.

To get the best weather resistance in a low-temperature stock, we would again select silicone rubber but would sacrifice toughness. The next best would be coated natural or nitrile and if coating was not practical, as in a solid section or bumper seal due to the mechanics of coating, FR-Neoprene would be used. This freeze-resistant chloroprene stock would not crack on low-temperature flexing, but it would be quite stiff, requiring high deflection forces and would not be weather resistant.

To get low-temperature and fuel resistance would require a nitrile compound. Here a compromise in fuel resistance must be made, as the plasticizers which impart good low-temperature flexibility are generally extractable in fuel. For a -40 F compound the swell-shrink range is generally not over 50% of the original volume of the compound; that is, for a room temperature exposure the swell on fuel immersion may be +35% and the shrink on drying might be as much as -15%. By adding the extreme low-temperature flexibility requirement the swell-shrink range would be greatly increased. To overcome this difficulty on o-ring seals, a special AMS committee is testing -65 F flexible compounds and will establish a procurement specification covering the best possible combinations of these properties. The chemical and petroleum industries are developing new nonextractable plasticizers for this group of compounds. Until these properties can be improved, designers must compensate for the shortcomings of the compounds in the design of seals and valves, or place these items on the list for periodic replacement. The age-dating program is a means of establishing a systematic replacement of parts before failure occurs.

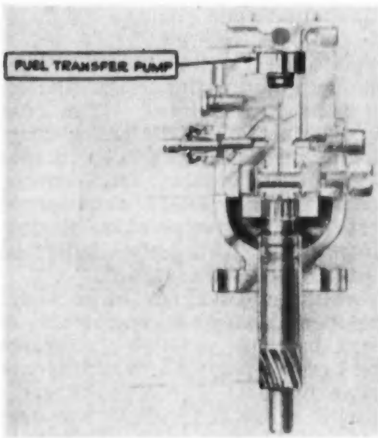
(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

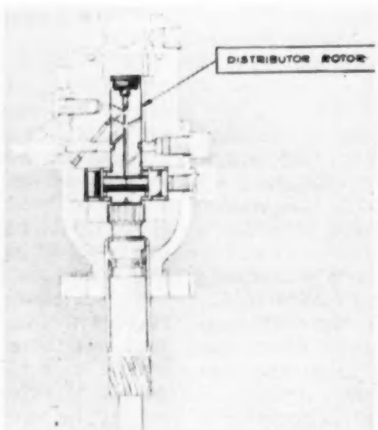
New Fuel Injector

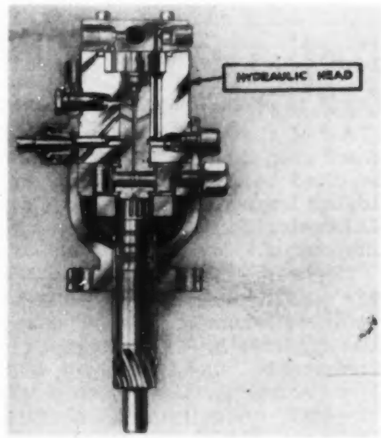
Vernon Roosa, Hartford Machine Screw Co., Inc.

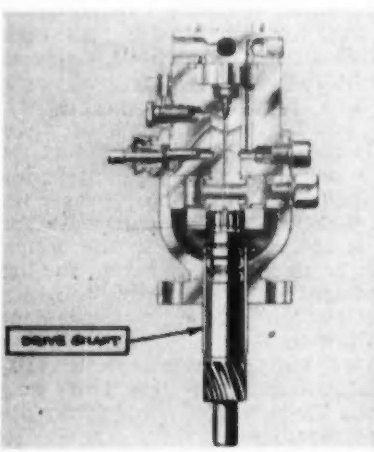
Based on paper "Simplifying Fuel Injection" presented at SAE Annual Meeting, Detroit, Jan. 15, 1953. Complete paper in multilithographed form may be obtained from SAE Special Publications Department at 25¢ a copy to members, 50¢ to nonmembers.

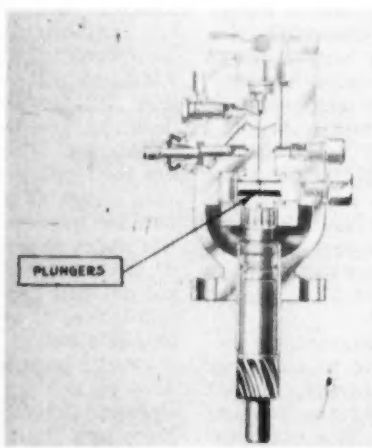
Its Parts

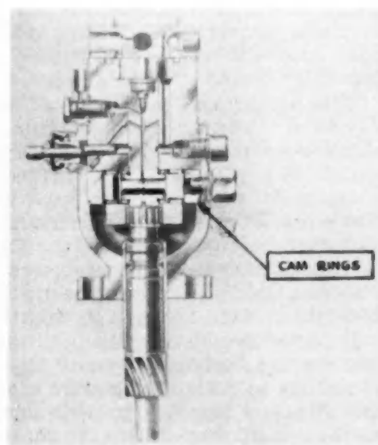






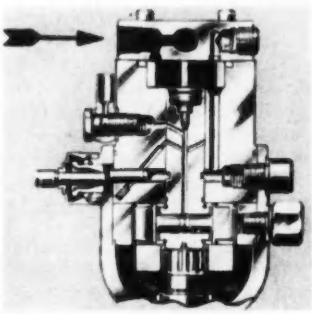






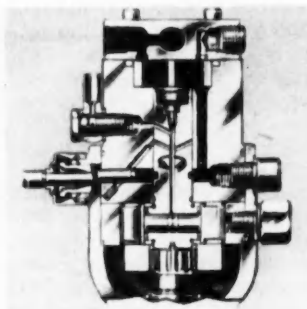
Spins as It Squirts!

Its Operation



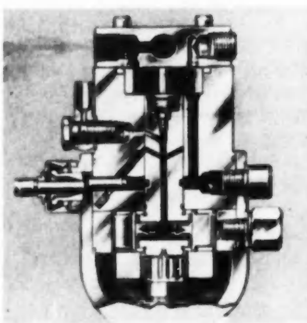
1.

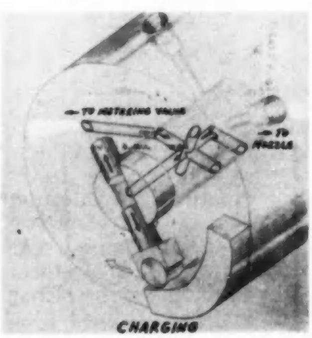
FUEL is drawn from the supply tank into the unit by a vane type transfer pump interposed between the end plate and the distributor rotor. Next it . . .



2.

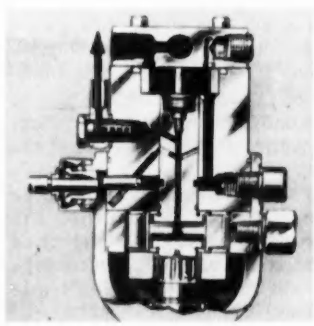
. . . Flows under pressure down and around to the metering valve. When a charging port in the rotor registers with the passage from the metering valve . . .

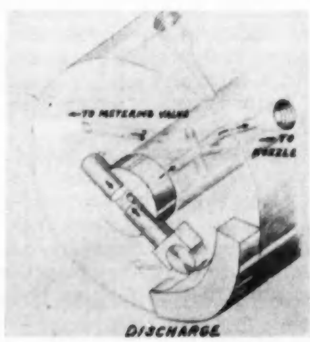




3.

. . . A metered charge of fuel passes down the axial passage in the rotor, forcing the opposed pump plungers outward. Further rotation causes the rotor outlet port to register with a discharge port in the hydraulic head . . .





4.

. . . At this time, the rollers rise toward the center of the cam, forcing the pump plungers together, and causing the metered fuel to be ejected up and out of the unit to one of the injection nozzles.

Its Characteristics

Size Roosa-Master fuel injection pumps are now made for 4- and 6-cyl diesel engines that operate up to 4200 rpm. (This amounts to 2100 strokes per minute per cylinder in a 4-cycle engine.) However, units can be made for 2-, 3-, and 8-cyl engines. The range of plunger sizes permits metering from 5 to 135 cu mm per stroke. Depending on type of mounting, drive, and governor used, weight of the unit varies from about 7 to 18 lb.

Mounting The fuel injector can be mounted in any position on either side of an engine for operation in either direction of rotation. At present the three most popular methods of mounting are flange, bracket, and vertical or distributor.

Drive A tang drive, which is the standard SAE distributor and magneto drive, is most frequently used. With the distributor type mount, drive may be through a helical gear. With bracket- and flange-mounted units, the conventional Oldham coupling is used or direct drive is effected by bolting the timing gear onto the pump hub.

Governor Three types of governing are employed with the Roosa-Master fuel injection pump—centrifugal, hydraulic, or the engine governor itself.

The centrifugal type rotates the metering valve through movement of the flyweights against the thrust sleeve. This in turn operates the governor arm connected to the metering valve. The metering valve, by rotating, opens and closes its slot leading to the inlet passageway.

The hydraulic type operates on the varying fuel pressure created by the transfer pump. It consists of a metering valve that slides in the hydraulic head, a spring which opposes fuel pressure created by the transfer pump, and a rack and pinion connected directly to the throttle through which the operator can compress this spring.

As engine speed increases, fuel pressure acting on the metering valve increases. This forces the metering valve up, compressing the spring and partially closing off the fuel passage. Result: less fuel admitted, hence lower engine speed. Conversely, as engine speed decreases, the spring forces the metering valve down, allowing more fuel to flow to the pump cylinder.

Stop Mechanisms Much has been said and a great deal written about starting engines, but they have to be stopped too. In the Roosa- Master pump with the hydraulic governor, a stop lever is provided that revolves the spindle on which it is supported and, through an eccentric, moves the metering valve to its closed position. In the model using the centrifugal governor, there are two methods of stopping the engine—one mechanical, the other electrical. In the mechanical type, fuel shutoff is accomplished by a linkage. A shutoff bar overrides a spring on the governor linkage, moving the metering valve to the closed position. With the electrical system, the same thing is done by a switch and solenoid.

Lubrication The pump is self-lubricated by the filtered fuel it pumps. When the fuel reaches the annulus of the rotor shank, there is a relief slot leading to the reduced diameter which permits it to completely fill the cavity of the housing. A return line allows the fuel to flow back to the tank at the rate of about 3 gal per hr.

Maximum Fuel Adjustment In the Roosa-Master pump, the maximum quantity of fuel that may be injected into a combustion chamber on each stroke is set by limiting the outward travel of the cam roller shoes. This is the only adjustment that can be made. It may be changed in the field if desired or required.

Calibration is inherent in the design of the pump. Better than 4% calibration between cylinders is achieved at full load. Calibration at part load never exceeds 10%.

Torque Characteristics Practically any desired torque characteristic curve can be met by the unit—varying from a flat delivery curve where maximum output is uniform regardless of speed to a curve which can be either high or low at either end of the speed range.

Discussion

The following questions and answers were brought out in discussion after the presentation of the Roosa paper.

Question: Has it been possible to finish the cam rings by hardening after machining and put them to work without benefit of a grinding operation?

Answer: The cam rings are ground after hardening.

Question: How many cam rings can be ground per stone?

Answer: We are still experimenting. Although we prefer not to divulge our manufacturing process, it can be said that we achieve more than 10 cams per stone.

Question: The method used for achieving variation of injection timing would seem to be very limited as to the amount of timing change possible. If the cam ring is turned in relation to the hydraulic head, then the plunger harmonic becomes unphased from the proper registering of inlet and outlet ports in the distributor rotor with corresponding ports in the hydraulic head. In the case of a 6- or 8-cyl pump even a small rotation of the cam ring would no doubt cause trouble on this score. Would the author care to give us the figures for timing range, expressed in crankshaft degrees, for his 6- and 8-cyl pumps?

Answer: The timing range would be approximately 16 deg of the crankshaft for the 6-cyl application. Although we have operated an 8-cyl pump, we have not as yet applied the automatic advance to it. We feel however that approximately 14 deg of the crankshaft could be obtained without difficulty.

Question: Have the rollers shown any tendency to develop flats after prolonged operation?

Answer: Visible inspections made after prolonged operation have not revealed any tendency to develop flats. This can be attributed to the fact that the rollers revolve in the cam roller shoes.

Question: It does not seem possible that in the case of a pump for an odd number of cylinders, the cam ring could have "as many oppositely spaced cam lobes as there are cylinders in the engine." What is the solution for the 3-cyl execution of the cam ring?

Answer: Injection for a 3-cyl engine is achieved by using the cam ring for a 6-cyl engine and eliminating every other inlet passage in the rotor and outlet passage in the head. We were probably not technically correct when we said the cam ring would have "as many oppositely spaced cam lobes as there are cylinders in the engine."

Question: Do the rollers follow the cam profile fully or do they show a tendency to float or creep in the ring?

Answer: The cam rollers follow the cam profile except where their outward travel is limited by the maximum fuel adjustment stop. This fact has been determined by use of a stroboscope, and observation of the rollers through a plastic window at the drive end, the pump being driven at that time from the transfer pump end.

Question: It would seem that any pump that ties retraction volume to cam ring configuration (for a given plunger diameter) might be wanting in flexibility of application to a variety of engine models. Would the author care to comment on this?

Answer: It is true that any single model of the Roosa-Master pump might not have a great flexibility in application to a variety of engine models. However, our flexibility is achieved by the various cam shapes and plunger sizes.

Question: One of the inherent features of any injection pump that works on throttled-intake control is a progressive retard of injection timing with reduced load at any set speed. In engines where high idle is a frequent requirement, this injection timing retard can lead to persistent misfiring, accompanied by blue exhaust smoke and nozzle fouling. This calls for some device that will automatically advance the timing with reduced load independently of anything which advances timing in re-

sponse to increased speed. How is this accomplished in the Roosa-Master pump?

Answer: Since automatic advance is dependent upon transfer pump pressure, it follows that at reduced load at any given speed there is a slight advance in the timing due to increased pressure.

Question: If pumps should develop increased flow of fuel back to the supply tank due to wear would this cause a pressure drop on the metering valve. Would this affect original engine performance?

Answer: If considerable wear existed, it might well cause a pressure drop on the metering valve. However, to date we have not experienced considerable wear due to careful selection of materials.

Question: How is relative motion between governor weights and the thrust sleeve absorbed?

Answer: The governor thrust sleeve does not rotate. Instead the flyweights revolve. They are pivoted on their outer edge and are free to produce an axial motion on the thrust sleeve. These parts operate completely submerged in oil. Torsional vibrations are absorbed thanks to the exposed areas of the governor weights in their retaining sockets.

Question: Is a 90 deg helical gear drive, such as a distributor uses, sufficiently strong to drive the pump for long periods?

Answer: It has been our experience that with the use of hardened gears, we have been able to compile many thousands of hours of operation without undue wear.

Question: How are various torque curves achieved?

Answer: The torque developed by an engine is for the most part influenced by quantity of fuel burned in the combustion chamber. Therefore, the torque of the engine will practically follow the delivery characteristic of the fuel pump provided the timing, rpm, and volumetric efficiency permit effective burning of the fuel charge.

The fuel delivery characteristic of the Roosa-Master pump at full load as first designed was almost constant from 400 rpm pump speed to 1500 rpm. For example, the maximum fuel delivery at 400 rpm pump speed was 50 cu mm, the delivery at 1500 was 51 cu mm.

When it is desired to have maximum fuel increase with decrease in speed, the procedure is as follows:

1. Maximum fuel to be burned at the peak of torque is determined; then the fuel pump is adjusted to this delivery by limiting the outward travel of the shoes.

2. The pump is brought to the maximum speed and maximum fuel being delivered is lowered to that desired by throttling the metering valve opening.

The governor is inactive during this operation since it is full load. Now, as the engine slows down from maximum speed, more fuel will flow through the throttled metering valve opening since the inlet ports are in registry longer. The quantity flowing is also influenced by the transfer pump pressure.

As the engine slows down, fuel flowing through the throttled metering valve will increase until at some lower speed, due to increased time and transfer pump pressure, the amount reaches the quantity necessary to fill the pump cylinder to the mechanically adjusted maximum fuel delivery.

If the pump delivery reaches the mechanically set maximum at a speed higher than that selected, then the transfer pump pressure curve is too flat, that is, there is not enough pressure differential between maximum speed and speed at the peak of torque. It follows then that the torque peak can be shifted along the speed range by varying the differential of the transfer pump pressure curve.

To illustrate this, we have two pumps both set for a mechanical maximum delivery of 60 cu mm which is reduced to 54 cu mm at 750 rpm by throttling. Pump A has a transfer pump pressure of 45 psi at 400 rpm and 60 psi at 750 rpm. Pump B has a pressure of 45 psi at 400 rpm and 75 psi at 750 rpm.

Pump B will need to have the metering valve throttled a great deal more than Pump A due to the 15 lb pressure difference between the pumps at 750 rpm. Hence, the speed of Pump B will have to be reduced a great deal more than Pump A before there is enough time at the lower speeds and pressure to attain the maximum mechanically set fuel delivery.

Question: What is the possibility of the torque characteristic changing due to wearing parts?

Answer: If there were wear, torque characteristics might change. However, to date no wear has been experienced which might cause changes in torque characteristics.

Notes on the use of Rivets and Other Fasteners

R. Lowell Hand, Lockheed Aircraft Corp.

Report of Panel on Fastening and Mechanical Joining held as part of the Aircraft Production Forum at the SAE National Aeronautic Meeting, Los Angeles, Oct. 1, 1952. Panel leader was S. N. Bean and panel coleader was L. E. Ganahl, both of Lockheed Aircraft Corp.

A VARIETY of problems concerning the use of rivets and other types of fasteners were discussed at this panel.

Flush Riveting

Countersinking must be used for heavy skins, although dimpling is satisfactory for thin skins.

Hot dimpling is used if the material cracks when the dimpling is done cold. The only method of hot dimpling now being used is conduction heating. Neither resistance heating or preheating is practical.

Hot dimpling of 24S-T is not permitted because the heat lowers the corrosion resistance of this material. Heat-aged alloys can be heated—and so they can be hot dimpled. Raising the temperature to only 300 F does not increase the permissible elongation for 24S-T to the same extent that it does 75S-T. It might be noted that Lockheed is considering hot dimpling 24S-T 86 (age-hardened). Some companies believe that it can only be done hot.

For extreme flushness, rivets can be driven using NACA standards wherein the rivet is put into the hole backward and the shank then headed down into the countersink to fill the depression. Diameter of the countersink is not critical.

Magnesium can also be dimpled, although the rivet driving does tend to split the material later.

Several methods of inspecting dimple dies having springback development are being used. Convair collaborates with the vendor as far as dimensions are concerned, but uses cerrobend to pick up the impression for their inspection. Douglas is trying a double-ring gage with knife edges and dial indicators, which are set to a master. Aircraft Tool Co. is using comparator reflection to check the intersection of the cone angle and face, however, the radius at this point causes the intersection to be indistinct.

Honeycomb structure is not dimpled unless the sheet was dimpled first. Spinning the dimple has been used to some extent; in which case, the cells are filled for support. In this application, a special 2-piece sleeve, which has a countersink in the sleeve head, is used. (Delron and Sta-Fast make these.)

Standardization of dimple cone dimensions on dimple tools presents no problems except on hole sizes and pilots. The only basic difficulty would be in getting companies to change their present standards.

Stainless-Steel Rivet

The stainless-steel rivet is used by Convair to provide a high strength/weight ratio, plus good corrosion and hole-filling properties. The load for upsetting is, however, greater than for Dural rivets.

The hole tolerance is not excessively close, so it can be drilled. The rivet has a hole in the end to assist in upsetting.

The material used is 302 H (cold-heading quality), with a design strength of 50,000 psi. The

Facts about fasteners presented in the accompanying story were given by this group of experts (left to right): H. J. Sumner, Convair; Frank Young, Douglas; Jack Kahlo, Northrop; Panel Leader S. N. Bean, Lockheed; Panel Coleader L. E. Ganahl, Lockheed; Joerg Litell, Ryan Aeronautical. At extreme right is R. L. Hand, Lockheed, secretary for the panel

rivets are cadmium plated to increase corrosion resistance. Even so, they still cannot be used under water on flying boats because of the likelihood of excessive corrosion.

The rivets are used only for high-strength fastening, where insufficient space is available for Dural rivets.

The rivets are cold-forged in smaller sizes and machined in larger sizes.

They are difficult to remove.

Blind Rivets

There are many types of blind rivets:

1. Du Pont—an explosive charge in the shank is set off by a hot gun applied to the head.
2. Cherry—(1) mechanical type, with a stem that pulls into the shank to swell it, and then snaps off; (2) pull-through type, with a stem that pulls out completely.
3. Huck—these are similar to the Cherry rivets, except for the type of grip on the stem. (These should not be confused with the Huck high-shear rivets.) (There is also a Huck blind bolt, a 5-piece high-strength fastener.)
4. Schobert—low-strength rivets that are magazine fed from a gun, giving a fast installation rate.

Blind rivets have the advantage over plate nuts in that they allow a saving in weight.

When holes are dimpled, they open up slightly, so that the blind rivets cannot fill the holes completely. This makes it difficult for the job to pass the retention requirements.

Automatic Riveting

The Drivmatic automatic drilling, countersinking, and riveting machine used at Lockheed has about a 3-sec cycle. The machine has electronic control and works on panels up to 30 ft in length. The spindle runs at 6000 rpm, with 0.006-in. feed per revolution. Feed is automatic.

The biggest problem is to handle the work in the machine. Lockheed uses special carriages with rails and contour bar supports. It is understood that Temco has improved the carriage application.

The rivet pattern is spray painted on the panel so that the operator can see that each rivet is going into the proper place. (Edge distance is accurately gaged from the internal structure.)

Burr is eliminated on the Drivmatic by proper cutter design, by a brush that knocks chips off the cutter at the end of each drilling cycle, and by proper air-jet application to remove the chips.

The hot Erco process combines hot dimpling and riveting in one operation. The hot conduction system developed by Lockheed was put on a Lockheed-reworked Erco. This machine has the usual levers replaced by electronically timed pneumatic pistons.

An upper shoe operating at 475-550 F contacts the work for an automatically timed period. A lower shoe is operated at a maximum of 375 F, to eliminate damaging the sheet if the operator leaves the part resting on the shoe too long. At Lockheed, Sim-Ply-Trol heat control units are used on the hot Ercos.

Heating time is 0.4 to 1.6 sec, depending on the material thickness. About 5-sec cycles are possible for 0.128-in. total thickness. Machines can be run cold by throwing a selector switch.

Punching the hole after dimpling does not give any trouble on an Erco. The rivets go in easily and the small burr that forms is covered by the rivet head.

Shaving of Rivet Heads

Corrosion of the rivet head is not considered serious even when the protective finish is removed from a steel rivet head by shaving; however, most experience has only been with shaved Dural and monel.

At Northrop, shaved steel is spot Iridite treated.

Leakproof Fasteners

Various types of leakproof fasteners are available. The Huck people believe that their products are very good in this respect, although the lubricant has to be removed from the Huck bolts so that the sealer will stick.

Seal ring rivets have been used by Boeing. Grumman has used rivets with high heads driven into the countersink. Lockheed uses high driven rivets and seals with a fill and drain sealer.

Fasteners for Inspection Doors

Present plans call for the use of high-strength, quick-release fasteners. We now have fairly good

strength but, of course, have lost the "float" principle, which allowed for poor coordination of holes. There are three classes of temperature limits: 250 F, 500 F, and 1200 F.

The old latch-type fasteners had to be locked, but some of the new ones can be slammed shut. All must have a positive indication when they are locked. We need a simple fastener that can be opened with a stick from the ground and then can allow the door to be slammed shut after the inspection.

Tolerances

Hole tolerances are specified on the drawings. If exceptionally close fits are required, reaming is used.

In regard to tolerances allowed for seating under the head of brazier rivets and for countersink on flat heads:

1. Lockheed permits a 0.004-in. gap in not over 10% of all rivets.
2. Northrop allows 0.004 in. for 1/8-in. diameters, 0.006 in. for 5/32-in. diameters, and 0.008 in. for 3/16-in. diameters.

When driving flush rivets, the head tends to mash in, so that the excess must be shaved off.

A countersink diameter is checked by actually trying the rivet or fastener in the countersink. In some instances—such as for bolts—a gage is provided.

Lockheed uses special close-tolerance fasteners and then gages the countersink to the fastener to meet flushness requirements.

Drilling

When using hand motors to drill:

1. Stainless—use special drill grind and keep the drill cutting.
2. Titanium—use a lower speed and be sure to keep the drill cutting.
3. Cobalt alloys (Haynes No. 25)—carbide with a flat point can be used in some cases.

Roll Pins

Beech has had no trouble with roll pins, even though no safety lock is used.

The Navy has not required safety locks for some specific applications. They have rejected roll pins for a control bearing, for example. In any case, there must be the proper relationship between length and diameter to give satisfactory service.

Human Relations . . .

. . . is aggregate of two-party relationships, no matter how large the group, and here's where bulk of human relations job must be done.

Based on paper by **Ben D. Mills** Ford Motor Co.

AT Claycomo, Mo., where we are to produce wings for the Boeing B-47 Stratojet bomber, we shall need 8000 employees at peak of production. We realize we cannot deal with this number as a single group for you cannot deal even with two people as an entity. The fact is we are dealing with 8000 individuals, no two of whom are exactly alike, and while some general policies will satisfy substantially all of our employees, we cannot hope to succeed unless we look on each employee as an individual.

In the main, our work is accomplished as the result of relationship between two people—the employee and his foreman, the foreman and his general foreman, the general foreman and his superintendent, and so on. It is a well established organizational principle that no man can work for two bosses, and whether we have two people or 200,000, each individual is actually working for one other individual. It is in this relationship that we feel a large share of the human relations job must be done.

The first question we have to ask ourselves is what it is we want from our employees. Obviously, we want their initiative, ingenuity, loyalty, respect, confidence and technical skill. More broadly, we want each employee to have the desire to do the best he can with whatever job he is assigned.

To earn these things from our employees is simple in theory. This attitude toward leadership, whether it be the management of an activity of this kind, the direction of a society such as ours, or command in the Army, can be earned only by demonstrating the right to these things by the manner in which we conduct ourselves. They don't come as a result of the uniform we wear, the wages we pay, or the memos we issue.

A supervisor who is sincere, fair, honest, considerate, objective, and friendly in his relations with the employees he supervises will find, if my experience is any indication, that his employees will not only recognize him as their leader, but also will do everything in their power to assure his success. His success, coupled with comparable successes on the part of all other supervisors, equals, in the aggregate, the company's success in whatever undertaking is involved. (Paper "The Harnessing of Hu-Manpower" was presented at SAE Kansas City Section Meeting, Oct. 7, 1952. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers.)

How Present-Day Turbine and

IN axial turbine engines, the problem of impact-ice formation is being solved by passing hot air, exhaust gas, or oil through hollow components likely to collect ice—and by heating inlet screens electrically. (Icing isn't much of a problem in centrifugal-compressor turbine engines.)

In piston engines, protection is most often accomplished by drawing moisture-laden air through an alternate intake and heating the air by engine exhaust. This method is effective against all three types of ice which plague the piston engine: impact ice, throttle ice, and fuel ice.

Turbine-Engine Protection

The inlet guide vanes and support struts are made hollow to allow the flow of hot compressor bleed air or combustion gas as a heat-transfer medium. Hot engine oil is sometimes used in those supports which normally contain oil passages, but hot gas is superior for use in the inlet guide vanes. Either heat applied electrically to the surface, or hot air, gas, or oil in a thin double-wall arrangement protects the accessory housing.

The smallness of the inlet-screen elements precludes anything but electrical heating. But the power requirements because of the high heat-transfer rates prohibit this system, even when an on-and-off cycling arrangement is used. Consequently, the general practice is to side-step the problem by designing screens that retract in an icing condition.

Fig. 1 shows the large quantity of ice accumulated during a moderate icing exposure on a turbojet-engine inlet without inlet screen. This is impact

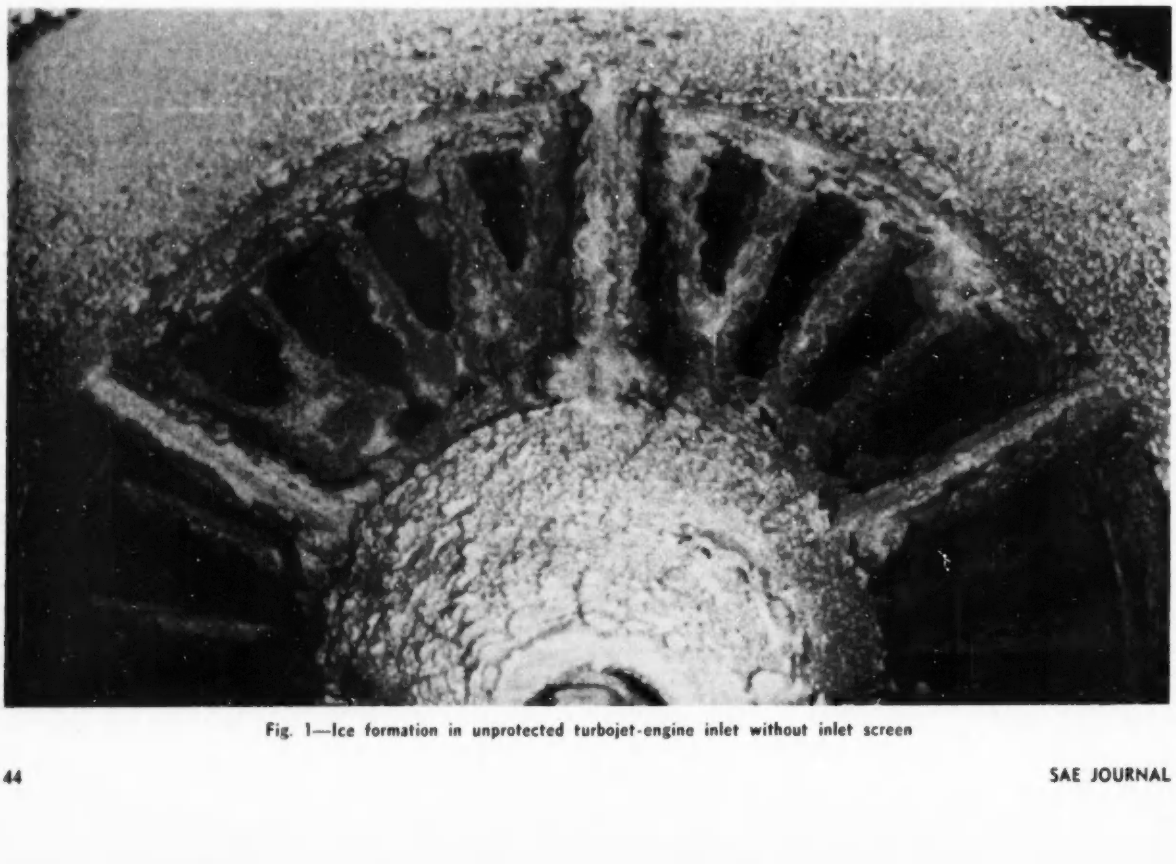


Fig. 1—Ice formation in unprotected turbojet-engine inlet without inlet screen

Piston Engines Combat Ice

Arthur A. Brown, Pratt & Whitney Aircraft Division, United Aircraft Corp.

Based on paper "Power, Thrust—and Ice" presented at SAE National Aeronautic Meeting, Los Angeles, Oct. 3, 1952.

ice—ice which exists in the atmosphere as snow, sleet, or subcooled water droplets. Impact ice forms only at 32 F and colder.

Protection against icing is particularly important because without it, a turbojet or turboprop could suffer a turbine failure. The reduced engine airflow caused by ice formations not only decreases thrust but increases the exhaust-gas-nozzle or tailpipe temperature. In severe icing conditions, the tailpipe temperature may rise above the safe operating limit in only a minute or two. Some modern engine controls do, however, compensate for airflow changes and prevent excessive combustion temperature rise, so that ice blockage eventually results in loss of engine speed as well as thrust. Actually, the tailpipe temperature and engine-speed readings give the pilot a sensitive warning of the presence of serious engine icing.

The propeller and reduction gear further complicate the icing problem in a turboprop engine. Fig. 2 shows what components in a typical turboprop air inlet the engine manufacturer must protect from ice. In practice, the engine manufacturer also cooperates with the propeller and airframe manufacturers in designing ice protection for the propeller and spinner and the cowl leading edge.

Both test stand and flight experience have shown that icing is not a serious problem with centrifugal-compressor type engines. Most of these engines employ a double-entry compressor protected by fixed screens. Inlet ducts are designed to remove a large portion of the incoming moisture from the airstream by inertia separation and to deposit this moisture in noncritical locations. During prolonged operation, some ice buildup may occur on the forward screen, but this is generally insufficient to cause an appreciable deterioration in engine output. At the present time, centrifugal-compressor turbines do not seem to require anti-icing.

Piston-Engine Protection

The most generally successful and most universal method of combating induction-system ice in a piston engine consists of using heated air drawn through an alternate air intake (Fig. 3). A preheat valve located upstream from the carburetor blocks off the ram air and admits air heated by the engine exhaust system. The preheat valve is usually a modulating type, so that a relatively high temperature can be obtained for the removal of ice accumulations, while a lower temperature can be used for continuous ice protection.

Alcohol or similar fluids are also used for ice removal, but only as a supplementary measure when sufficient heated air is unavailable. Tests have shown that alcohol sprayed into the induction system is at best a slower and less efficient remedy than the proper amount of heated air. It does, however, provide a desirable auxiliary when an engine has

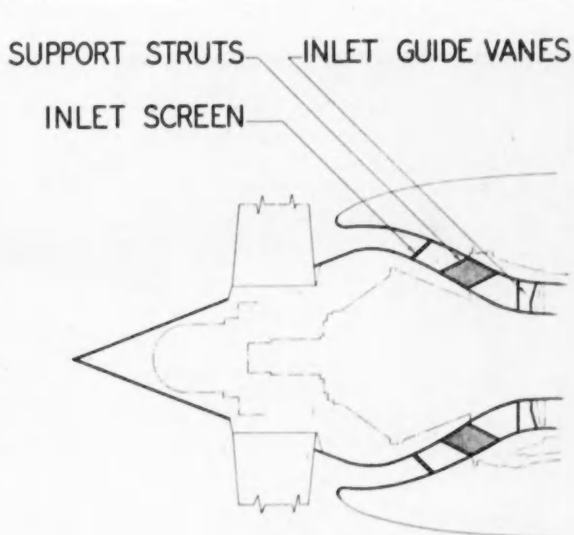


Fig. 2—Typical turboprop-engine inlet showing critical components that must have ice protection

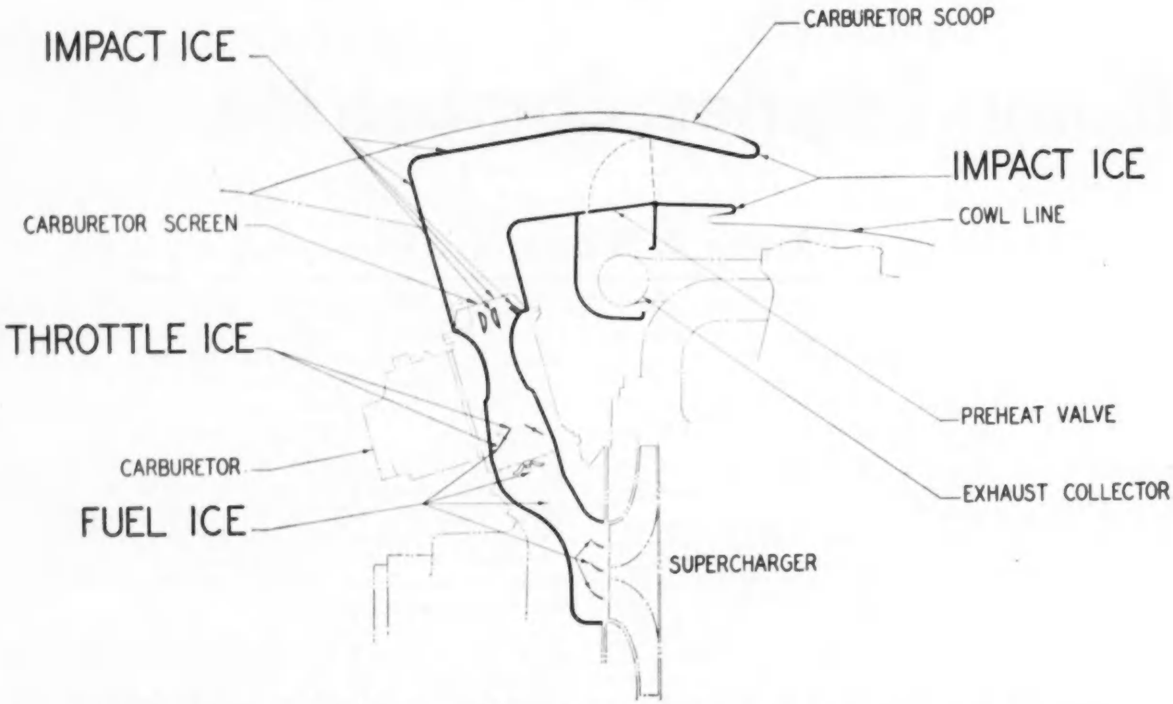


Fig. 3—Typical piston-engine air-induction system showing critical locations where throttle ice, impact ice, and fuel ice accumulate

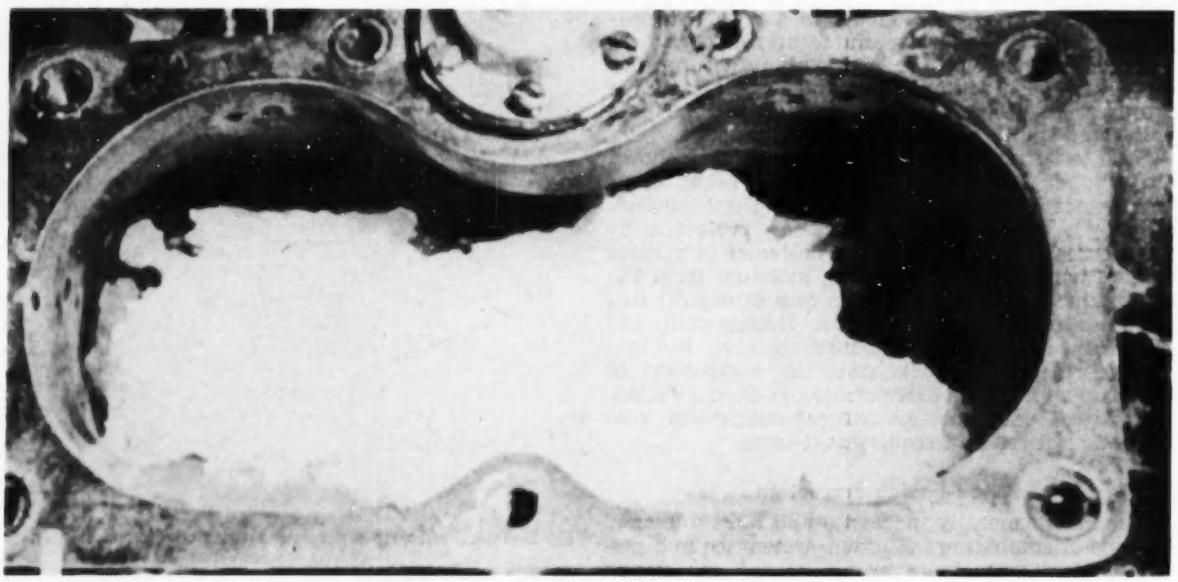


Fig. 4—Fuel-ice formation has almost completely blocked this supercharger inlet

almost stopped, during short periods of severe icing of the carburetor screen, or if the preheat door should become jammed with ice.

For a number of years, the use of preheat and possibly supplementary alcohol de-icing has been standard operating procedure in any atmospheric condition conducive to engine icing, and reported icing incidents have almost always been attributable to variations from proper procedure. More recently, there have been some cases of engine malfunctioning which have been traced to changes in mixture ratio caused by internal ice in the carburetor air metering passages. This type of ice can usually be prevented or removed by the proper application of preheat.

Heating intake air works well against all three types of piston-engine ice formation:

1. Fuel Ice—This type is the worst from the operator's viewpoint. Fuel ice can form with induction air temperatures well above 32 F and without visible evidence of moisture. It occurs after injection of the fuel into the airstream as the fuel is vaporized, with a resultant marked temperature drop. With certain types of carburetors, this ice forms when carburetor air temperatures are as high as 100 F. Fuel ice tends to accumulate on any protuberance near or downstream of the fuel-injection nozzle, resulting in airflow or fuel-flow blockage, fuel-to-air-ratio changes, or disturbance of mixture distribution to the cylinders.

Fig. 4 shows a fuel-ice formation which caused almost complete blockage of the supercharger inlet.

2. Impact Ice—This type is snow, sleet, or subcooled water droplets. Inertia separates this ice from the induction air stream and deposits it on various surfaces. Impact ice is most dangerous when it collects on the carburetor metering elements because rapid changes in fuel-to-air ratio can result. Ice deposits on the carburetor screen, scoop walls, and elbow can block airflow, and accumulations on the preheater valve may render it inoperable. Impact ice can only occur at free-air temperatures of 32 F and lower.

3. Throttle Ice—This type forms when particles in the kinetically cooled, high-velocity air stream in the throttle body are deposited on the throttle plates and adjacent parts. For a fixed throttle setting, this ice reduces power by blocking airflow. Although the free-stream temperature drop may be as much as 90 F, most of this is recovered at the ice-collecting surface, so that throttle ice is not observed at induction air temperatures above 39 F.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Altitude Test Chambers . . .

. . . now under construction will likely shift use of flying test beds to advanced and final phases of development when flight is needed to experience actual conditions.

Based on paper by **Lt.-Col. D. M. ROSS** Wright Air Development Center

ESTABLISHMENT of extensive laboratory test facilities by the U. S. Navy, National Advisory Committee for Aeronautics, and U. S. Air Force, and test facilities at contractors' plants, will make available several large altitude test chambers for testing turbojets and turboprops under simulated high-altitude and high-speed conditions. In addition, the five makers of turbine engines have been provided with North American B-45 aircraft for modification and use as flying test beds.

A B-45 modification, including instrumentation, represents an investment of about $1,750,000, and takes about 9 to 12 months. The cost of using a test bed by a contractor, exclusive of the experimental engine, varies from $300,000 to $550,000 per year, depending upon details of the particular program.

If a flying test bed is utilized effectively it should accumulate 100 hr of experimental engine test time a year, though this rate may not be attained until the bed has been in use for 9 to 12 months. Thus the cost of use ranges between $3000 and $4000 per engine hour.

In contrast, the typical altitude test chamber will accumulate approximately 500 hr of engine test per year, assuming it is staffed on a two-shift five-day week basis with air blowing and exhauster facilities available on a one-shift basis. Some chambers will likely exceed this rate. The number of test chambers being provided per facility in the new Government laboratories varies from two to four. The estimated cost of operating a facility with three test chambers is $3,000,000 per year, thus the cost of an hour's test time is approximately $2000. The cost of establishing a ground test facility with two or three altitude test chambers ranges from $15,000,000 to $25,000,000 and it takes from four to five years to design and construct.

The role of the flying test bed is expected to continue unchanged for the next 18 to 24 months. Then, as the new altitude test chambers become proven facilities, we can expect the test beds to be used for the more advanced and final phases of development tests in which flights must be made to experience actual conditions. The part to be played by the test bed in development of turboprop propeller combinations will undoubtedly continue strong because of the importance of transient tests and of testing the engine-propeller combination.

(Paper, "Ground Facilities—Altitude Test Chambers, Advantages and Limitations," was presented at SAE National Aeronautic Meeting, Los Angeles, Oct. 4, 1952. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers.)

Loop Scavenging Used

A SMALL, high-speed, 2-stroke, loop-scavenged diesel engine has been developed for automotive applications. It has been designated the model 51.

There are both 2-cyl and 4-cyl models, with a bore of 4.1 in. and a stroke of 4.1 in. A stroke to bore ratio of 1/1 was adopted because it was felt that when the inlet and exhaust ports are adjacent, as in the loop-scavenged engine, better scavenging is obtained than with a ratio of more than unity.

The basic design has been arranged to suit various applications. Fig. 1, for example, shows the 4-cyl model for trucks and buses. It is complete with belt-driven vacuum pump, composite flywheel and clutch housing, and limiting speed governor. It has been given extensive proving ground and field tests, installed in 16,000-lb trucks. In auto haulaway service, fuel economy has averaged 9 mpg. Engine weight is about 60% greater than for its gasoline counterpart.

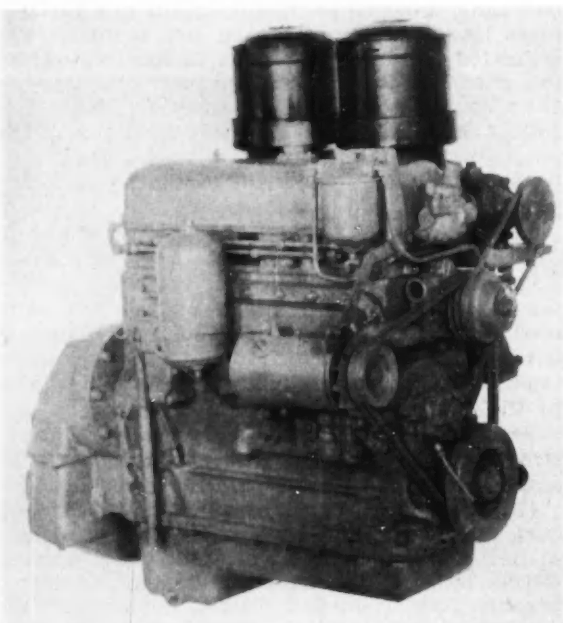


Fig. 1—4-cyl model 51 engine built for truck and bus use

A 4-cyl marine model has also been installed in both pleasure craft and work boats. It is rated at 87 hp at 3000 rpm for the former and at 54 hp at 2200 rpm for the latter boats.

The 2-cyl model is being used in such applications as to drive compressors and electric generators.

Performance

Performance and other characteristics of the engine are shown in Figs. 2-8. The full-throttle performance curves of Fig. 2 show a torque peak at 212 ft-lbs and 1800 rpm and a torque curve generally parallel to that of representative gasoline engines of the same speed range. For full throttle a minimum fuel consumption of 0.465 lb per bhp-hr is obtained at 2500 rpm. The rather high values of fuel consumption shown at the lower speeds are due to a characteristic of the injectors, which deliver somewhat more fuel at these speeds than the engine can comfortably burn. On truck engines a fuel modulating device is added to the governor to limit the fuel injected per cycle to essentially a constant value throughout the speed range. Characteristic fuel consumption curves are given in Fig. 3. The same data are replotted in Fig. 4 to show a complete picture of engine performance. It will be noted that a minimum fuel consumption of 0.44 lb per bhp-hr exists in the region from 1400 to 1800 rpm and at a bmep of 55 psi.

Air consumption data are given in Fig. 5. The observed cfm is very nearly a straight line varying directly with speed and the charging pressure is very close to a parabola, confirming the design assumption that the engine may be considered an orifice as far as airflow is concerned. Excess air is nearly constant, with a peak of 34% more than piston displacement at 1000 rpm, and dropping to 29½% at 2800 rpm. The overall fuel ratio has little combustion significance, since it is based on the total amount of scavenging air supplied to the engine. The lower values at lower speeds reflect mainly the larger amounts of fuel delivered at these speeds when the fuel modulator device is not used. Full-throttle heat rejection curves are shown in Fig. 6. Specific heat rejection to the water is 34 to 35 Btu per bhp-min in the operating range of the engine, with the higher rates at the lower speed again attributed to excess fuel at the lower speeds. Overall thermal efficiency is just under 30%. Total heat rejection at 3000 rpm is 3300 Btu per min.

In small engines it is essential that a maximum amount of the air trapped in the cylinder be made

in New 3000-Rpm Diesel

John Dickson and Roger D. Wellington
Detroit Diesel Engine Division, GMC

Excerpts from paper, "General Motors Model 51 Diesel Engine," presented at the SAE Annual Meeting, Detroit, Jan. 15, 1953.

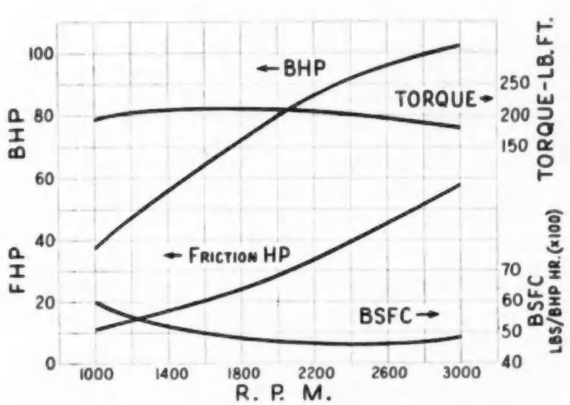


Fig. 2—Full-throttle performance curves

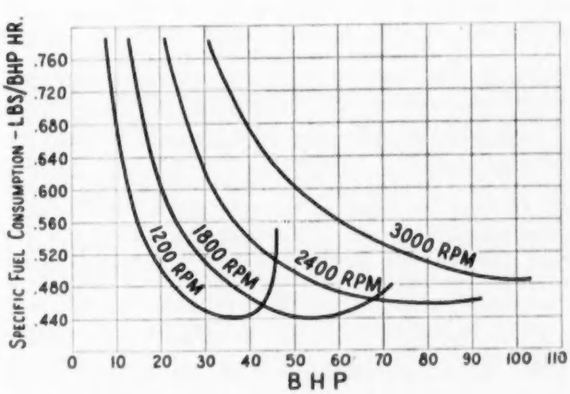


Fig. 3—Characteristic fuel consumption curves

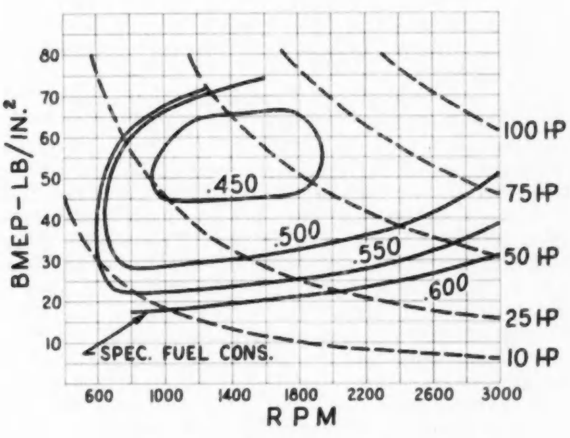


Fig. 4—Performance curves

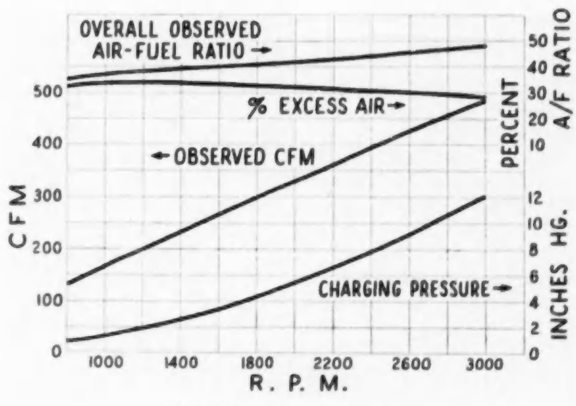


Fig. 5—Air consumption curves

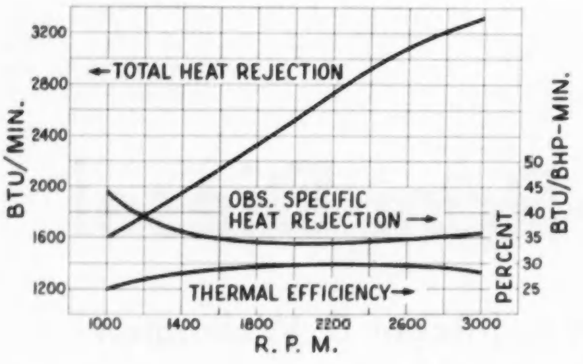


Fig. 6—Full-throttle heat rejection curves

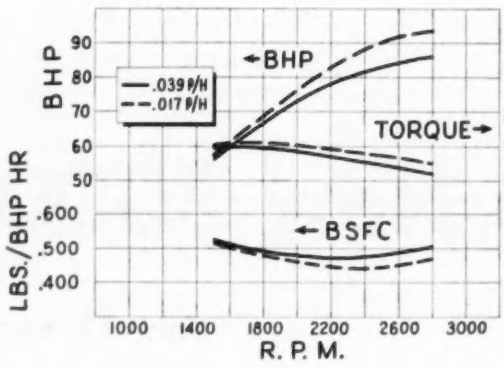


Fig. 7—Effect of piston-to-head clearance on performance

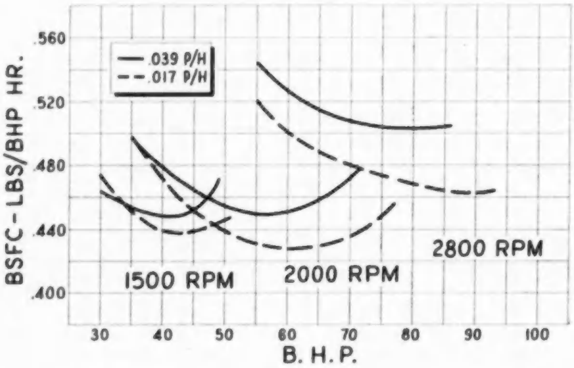


Fig. 8—Effect of piston-to-head clearance on fuel consumption

available for combustion. In an open-combustion-chamber engine, such as the model 51, a minimum piston-to-head clearance is required. The effects of varying the piston-to-head clearance are shown in Figs. 7 and 8. Although a stackup of tolerances allows considerable variation, it is remarkable how production tooling has held this clearance in the neighborhood of the desired 0.020 to 0.025 in.

Scavenging

As you can see from Fig. 9, we placed the scavenging blower and the exhaust manifold on the same side of the engine. Thus, the scavenging air passes up and to the sides and through the back of the cylinder liner, flows up toward the cylinder head, loops around, and discharges on the same side from which it entered. This particular flow path was adopted in order that cam and balance shaft, and push-rods, could be accommodated on the side opposite to the blower.

Experimental work has been done with the blower on the opposite side from the exhaust. The blower, in this case, was situated high, with guide vanes installed to direct the airflow upward.

There does not appear to be much to choose between the two arrangements of airflow. We are of the opinion (and this is a factor that may be often overlooked, in the design of a scavenging system) that the piston walls have a very important influence on the direction of the airflow, particularly if the air before entering the cylinder is directed toward the cylinder head. The shape of the crown at the rim of the piston does not appear to be of much consequence. The first air that enters the cylinder has a direction influenced by two factors, the angle of the intake ports, and a component that is directed by the piston itself, as shown in Fig. 10. The scavenging is thus a sweeping angular movement toward the exhaust ports as the piston approaches bottom dead center. It appears to be essential, particularly in the early stage of the scavenging, that the air be directed with the minimum of turns and bends towards the cylinder head, and the remainder of the scavenging cycle will take care of itself. In the cylinder block, the liner support is eliminated between cylinders to give maximum passage for airflow. Also, closing the passage at the back of the liner, as shown in Fig. 11, was found to improve scavenging. The exhaust bridges are water cooled, as shown in Fig. 11.

Since the engine is a relatively high-speed engine at 3000 rpm, the time area of the porting arrangement is very important. The area of the ports has to be so proportioned that there is a relatively easy flow of air into and out of the cylinder; otherwise, the airbox pressure, the blower horsepower, the overall engine power loss, and the fuel consumption would be high.

From our experimental work, an airbox pressure of 11 in. of mercury at 3000 rpm appeared to be a reasonable figure to design for. This compares with a figure of 16 in. of mercury at 2000 rpm being obtained on the uniflow engine. Fig. 12 shows the time-area diagram. There are 10 intake ports and three exhaust ports. Intake ports are 0.50 in. wide and 1.06 in. high, the exhaust 0.71 in. wide, and 1.51 in. high. Blowdown time area at 8.22 sq in.-deg is a reasonable figure for this size engine. The height of the exhaust ports is important, as this height determines the amount of fresh air it is possible to trap in the cylinder and, thus, the bmep that can be expected.

The height of the exhaust port being 1.51 in. gives a working trapped air stroke of 4.1 minus

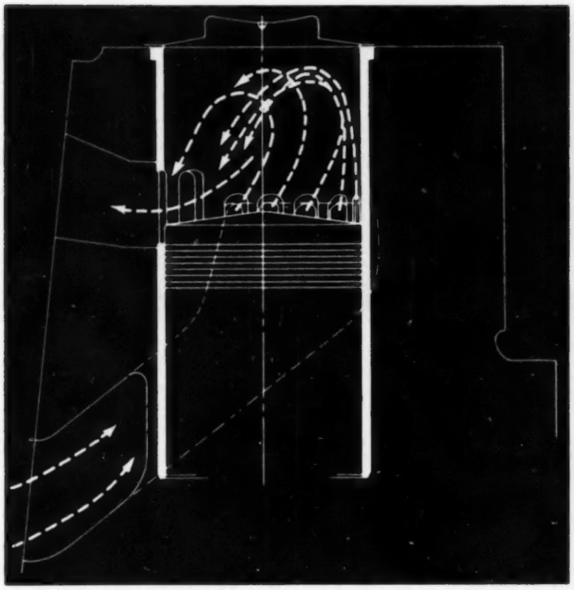


Fig. 9—Diagrammatic view showing how air flows from scavenging blower into cylinder and thence to exhaust manifold

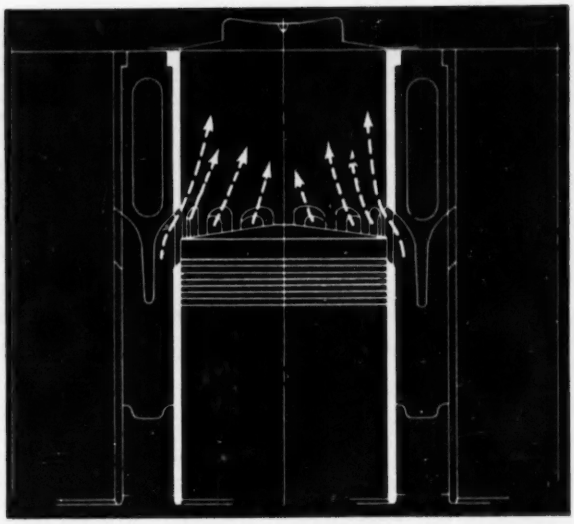


Fig. 10—Diagrammatic view showing how air flows into cylinder from intake ports

1.51 in., which is equal to 2.59 in. or 63.2% of the total stroke. Then, allowing 100 psi bmep as the figure to be expected from a cylinder completely filled with air, this would give 63 bmep as a reasonable figure for the model 51 engine.

Combustion

The combustion chamber is machined into the head. The piston crown is shaped as a shallow cone, providing strength against gas loads and simplicity against thermal stresses. Locating the combustion chamber in the head instead of in the piston puts it in the normal path of the scavenging air, which is directed up through the inlet ports to the underneath side of the head. In the early development of the engine, problems of scavenging, injection, and combustion-chamber shape had to be attacked simultaneously. Never could it be told for sure just what was limiting engine power. After finally reaching designed output and being reassured by lengthy calculations that air was available for the amount of fuel we felt it necessary to inject, the problem of combustion-chamber development was undertaken in earnest.

In seeking a solution for the combustion space design, we tried out three different types during the development. They are shown in Fig. 13. The first one is known as the "bat wing" design, the second the "divided chamber," and the third, the "toroidal chamber."

It can be said that finally all gave the same results as regards fuel consumed per horsepower. As far as exhaust smoke was concerned, there was not much to choose between them. In all, about 30 different "bat wing" designs were tested. For a while it looked as if the "divided chamber" would take precedence over the "bat wing." The "di-

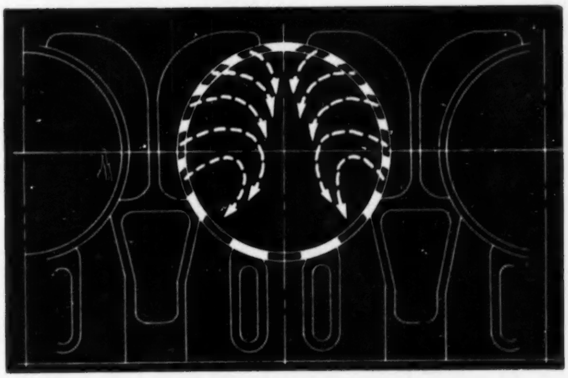


Fig. 11—Top view showing airflow

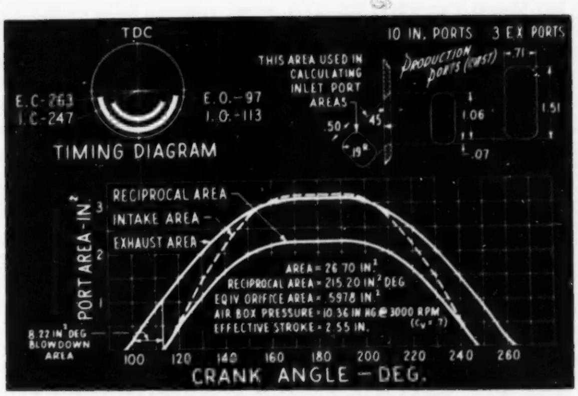


Fig. 12—Cylinder-liner time-area diagram

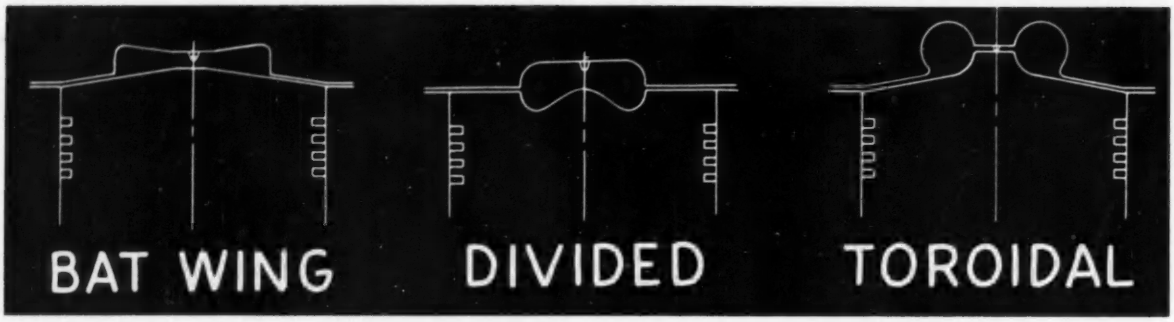


Fig. 13—Types of combustion chambers considered in developin the engine. The "bat wing" was finally chosen for production

vided chamber," with its wider piston crown, had a tendency to burn at the inner diameter of both piston and cylinder head. The addition of radii at the inner diameter proved detrimental to combustion economy. The "toroidal chamber" was designed and tested after the work on the other two was near completion. The immediate results were remarkable, as any attempt at change gave poorer results.

In each of the designs the problem was essentially that of fitting the combustion chamber to the spray, or vice versa, which is done largely by cut and try. Specifically, sprays may not overpenetrate because fuel which finds itself on the combustion-chamber walls is not only chilled, but finds air unavailable for its burning. Operation of the engine established 0.005 in. as the limiting diameter of the spray tip hole. Enough of these holes, then, must be provided to give a reasonable injection pressure and a proper spray distribution throughout the chamber. Ordinarily, seven or eight holes are found to be best, but in this case 10 holes were required as a concession to injection pressures. Measurements indicate the model 51 injection pressure to be 87½% of that determined for the model 71 engine, despite the fact that the smaller engine runs at 3000 rpm, compared to 2000 rpm. Having established the size and number of holes, we then varied the spray angle along with combustion-chamber-shape changes in a series of tests to determine the optimum. Again, the procedure was to let the engine tell us what it liked best. If we increased the radius in the corner of the combustion chamber, thinking to force the air into the vicinity of the sprays, but found more smoke, then the next chamber had a smaller radius. If signs of spray impingement were found on the piston crown, spray tips were changed to ones having a greater included angle. Compression pressures were watched at every step to assure the maintenance of the ratio previously determined as necessary for starting.

It is of particular interest to note that, during this course of development of three radically different shapes of combustion chamber, each gave essentially the same performance. This would lead one to believe that there are probably several good solutions to the combustion-chamber problem and that each, pursued to its optimum, would show little to choose between them.

The "bat wing" design was finally adopted for production.

Blower

A Roots-type blower is used on the engine. For simplicity 2-lobe rotors are shrunk on hardened steel shafts, which run directly in the aluminum end plates as bearings. The bearings are pressure lubricated through drilled passages and a counterbore and drain hole at the inner end of the bearing prevents oil pressure from building up on the face-type seal. The seal itself is a phenolic resin plate driven by lugs similar to automotive water pump seals. It is urged into contact with the blower end plate by a 5-lb spring load. Sealing to the shaft is accomplished by an O-ring.

A nominal metal-to-metal clearance of 0.025 in. between the blower lobes and between the lobes and the blower housing is packed by a 1/32-in. flock coating. The first few hours of operation rub the flock down to a nice running clearance, which assures a blower of a slightly higher efficiency than normal construction. The flock, which is similar to that applied to record player turntables and to the inside of automobile glove compartments, is sprayed onto a special adhesive in the valleys of

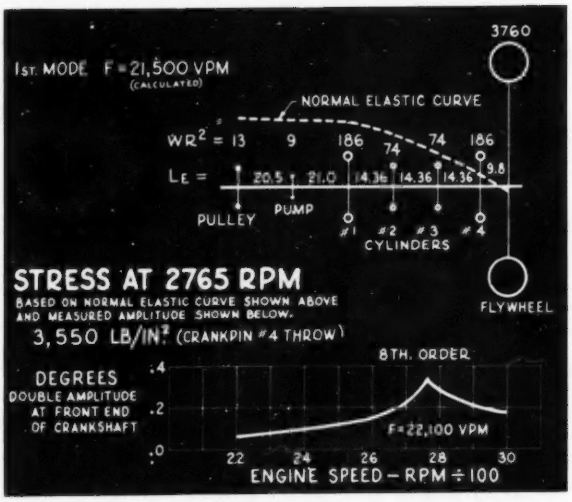


Fig. 14—Normal elastic curve and amplitude curve

the rotors and on the end plates and inside of the housing. With this method, none of the flock is subjected to high centrifugal forces nor in any place does flock rub against flock.

The blower is designed to give 30% excess air over engine displacement. This excess holds pretty well over the usable speed range. The actual figure was selected after tests were made with various blower drive ratios. We found that more air would result in a loss of performance at high speeds, although improving somewhat the performance at low speeds.

Crankshaft

A husky crankshaft having 3.62-in. diameter main journals and 2.625-in. diameter crankpins is supported in five main bearings. The maximum bearing pressure on main and connecting-rod bearings is 2100 psi and 3330 psi, respectively. A calculated natural frequency of 21,500 vpm for the first mode of vibration brings the eighth order at aproximately 2700 rpm. A viscous damper was incorporated in the early units, but was removed from the specification when the measured amplitude of vibration showed less than 0.4 deg double amplitude. (See Fig. 14.) The vibratory stress is calculated to be 3550 psi. The engine employs a simple and effective system of balancing. The crankshaft is counterweighted to balance the revolving couple of the crankshaft and, together with balance weights located at both ends of the camshaft, balance the primary reciprocating couple. Firing order is 1.3.4.2. - 90 deg.

Rear Crankshaft Oil Seal

A piston-ring-type seal was developed for this service since the perpherial speed of the crankshaft is more than 3000 fpm, which precludes the use of lip-type seals. Two piston rings are assembled into a carrier, which slips over the end of the crankshaft and is held in place by the flywheel. A crush ring is assembled between the crankshaft gear and the seal-ring carrier. The seal rings run directly in a bore of the flywheel housing, where, due to the very light loads, there is very little wear, even after extended periods of service. Surface finish of the flywheel bore is not important, since good sealing was obtained with the bore deliberately made to a finish of 150 microin. The bore, however, must be round, even after the housing is bolted up against the engine. The seal rings themselves must be round in the assembled position—and this has best been obtained by eliminating the high point pressure usually found in piston-ring applications. A typical diagram of ring wall pressure is shown in Fig. 15. A step-type joint has been used, but is not considered necessary.

Cylinder-Head Gasketing

With the one-piece cylinder head, individual compression, oil and water sealing gaskets were adopted in preference to the generally used one-piece gasket. The compression seals are laminated, compressible metal rings, which are held in exact location over the cylinder liners by a flange. The oil and water seals are O-rings of rectangular cross-section that fit into counterbores provided around

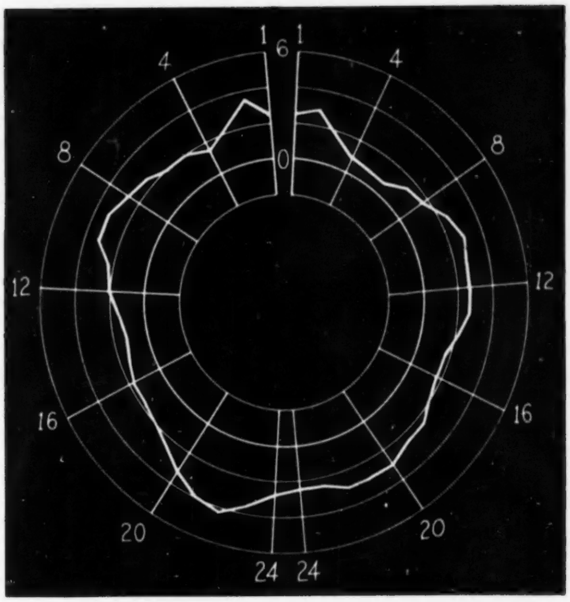


Fig. 15—Typical diagram of piston-ring oil-seal wall pressure

each water and oil hole, but project over the surface of the block. The holding down load is thus concentrated on the sealing surfaces rather than being spread over the head and cylinder-block surfaces. There is a space between the head and block, which makes gasket failure easily observed. Thus, if a compression gasket starts to leak, gas is released to the atmosphere without affecting the rubber seals of the water passages, eliminating the chance of loss of water, which has occurred with the one-piece head-to-block gasket. An additional feature of the gasketing is that heel pads are used at the extreme ends of the block to minimize cylinder-head distortion and gasket loading due to overhang of the extreme outside bolts.

Governor

A relatively inexpensive air governor was developed for the less exacting services. Sandwiched between the air cleaner adaptor and the blower inlet flange is an aluminum housing containing a butterfly valve, past which most of the air drawn in by the blower must go. In parallel with the butterfly valve passage is a venturi, the throat of which is connected by steel tubing to a governor diaphragm housing located on the cylinder head underneath the rocker cover. Vacuum developed by the venturi balances a spring-loaded diaphragm, the motion of which is transmitted to the injector control arms through a suitable linkage. For any setting of the butterfly valve, there is a corresponding engine speed that will develop in the venturi throat and, consequently, at the diaphragm sufficient vacuum to balance the pull of the governor spring. Any increase in speed results in higher vacuum and a motion of the governor diaphragm in a direction to reduce fuel. Conversely, a lowering of engine speed will act to increase the fuel delivery. This basic device has also been altered

to make a vehicle-type governor where engine speed control by the governor is desired only at idle speed and above some set full-load speed. This is accomplished by a special linkage, which serves to open the butterfly valve from its idle position to full-speed position with relatively small motion of the throttle or accelerator pedal. A branch of the linkage extends through the cylinder head and serves to limit the travel of the governor in the open direction. Continued motion of the throttle allows more and more fuel to be injected until full-load fuel is reached.

Lubrication System

An internal, gear-type pump lubricates moving parts through drilled passageways. Oil is drawn from the oil pan sump, at the rear of the engine, by the pump located on the front end of the crankshaft. Passages are drilled from the pump direct to the oil cooler and then to the hollow camshaft, at the center of the block. Tubes are pressed into grooves at the camshaft journals so they protrude into the inside diameter. Clean centrifuged oil is fed to the camshaft, main, and rod bearings through the camshaft tubes. Any particles of metal or grit carried in the lubricating oil are deposited on the periphery of the hollow camshaft. Passages from the main bearings lubricate bearings of the blower rotors, idler gear, and blower drive gear.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Excerpts from Discussion

Navy Tests of 4-Cyl Version

—**Alan R. Schrader,**
U. S. Naval Engineering Experiment Station

A 4-cyl version of the model 51 engine has recently been undergoing comprehensive tests at the U. S. Naval Engineering Experiment Station. In general, our performance results parallel those reported by the authors, although an exact comparison is not possible because we have a fully equipped marine engine, whereas the results reported by the authors are presumably with an unequipped engine.

As a result of our tests, we have assigned the engine a tentative power output rating of 70 bhp at 2100 rpm for marine propulsion applications in the Navy. This might be considered to be at variance with the designer's viewpoint that the engine is inherently a high-speed unit because of its relatively low bmep characteristic. However, the moderate speed that we selected—2100 rpm—was based on a desire for maximum reliability and service life.

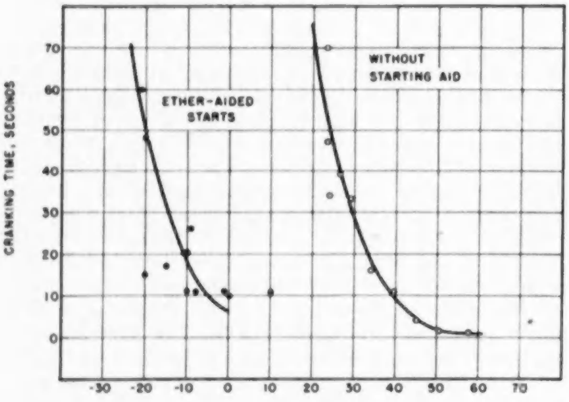


Fig. A—Cranking time required to start 4-cyl Navy version of model 51

We have tested the cold-starting ability of the engine. Fig. A shows the cranking time required to start the engine at various ambient temperatures. Without a starting aid, the engine was successfully started at temperatures down to 23 F. With ether injected into the intake air as a starting aid, the engine started at temperatures as low as −21 F. This performance was as good or better than most other small engines on which we have conducted cold-starting trials. We found no particular difference in starting effectiveness between the manual pumping of ether into the air intake or the use of pressurized metal capsules, although the latter method was more economical in the use of ether and is considerably safer from a fire hazard standpoint.

The results of the ether-aided starts were somewhat erratic as regrads the length of cranking time required to start the engine. It is probable that greater consistency and improved starting would result if experiments were made to determine the best place to inject the ether and to find the best correlation between ether injection timing, cranking, and throttle handling.

Loop-Scavenged Engine Is OK for V Arrangement

P. H. Schweitzer
Pennsylvania State College

THE loop-scavenged engine lends itself eminently to the V arrangement partly because of its unencumbered cylinder heads and partly because in a V a greater center distance is available between cylinders. Due to the scavenging airflow the loop-scavenged engine requires a greater center distance, approximately 1¾–2 times the bore, which makes the engine longer. But in a V engine the center distance necessitated by the main and conrod bearings is adequate to accommodate good scavenging airflow. The GM 51 center distance is approximately 1.34 × bore, which is a little skimpy and which in turn helps to explain the high fric-

tion horsepower, as shown in Fig. 2.

The scavenging is greatly affected by the guidance of the scavenge air. In the vertical plane the guidance appears excellent, as shown in Fig. 9, but in the horizontal plane, as shown in Fig. 10, it leaves something to be desired, unless you believe those inked arrows.

The specific fuel consumption, as shown in Fig. 3, varies greatly with speed and load and to achieve fair fuel mileage a lot of gear shifting would be necessary always to select the economical speed for any load.

Short stroke is attractive, but we pay a price for it. Other things being equal, 10% shorter stroke necessitates approximately 17% higher airbox pressure. But even with 12 in. of Hg airbox pressure 35 psi friction mep is pretty high (64% mechanical efficiency).

I can find with equal ease many excellent features in the design of this engine. The jet piston cooling, the lubrication system, the simple pneumatic governor, the sealing of water and air without rubber rings on the liner are attractive features. The draining tubes at the low point of the airbox are all right, but why must the air and oil spill to the floor?

In conclusion, I wish to emphasize that, in my view, this is a very encouraging development which promises to reduce the cost of diesel power, particularly in highway transportation.

Economy Runs . . .

. . . establish a mileage par for motorists, thereby revealing potentials in modern cars and challenging drivers to improve their skill.

BASED ON PAPER BY **W. S. Mount,** Socony-Vacuum Oil Co., Inc.

THE mileage capabilities of both cars and gasolines are improving steadily, yet the driving public is still on a national year-around average of 15 mpg. The car owner rarely approaches the potential built in it for him. What appears lagging, though improving, is public knowledge of, and interest in, the attainable mileage level and the means to reach it.

What economy runs do is demonstrate the high economy potential in the modern car and tell the public how to capitalize on it. They set a mileage par which few will attain, but which still has value as a goal. Economical driving is safe driving. Indiscriminate speed, jack rabbit starts, and cresting hills at high speed have no place in economical driving.

The influence of our Run on new car design is indirect. The Run has shown what could be done with modifications of rear-axle gear ratios. It was a factor in the development of dual range automatic transmissions, and has popularized overdrive. Experience with altitude effects has focused attention upon the newer, more complicated carburetors, and it has put emphasis on well-balanced gasoline, especially on volatility.

The 1952 Run left the distinct impression that reasonably high power is a factor in economy if kept in reserve until needed. Our obligation, therefore, is to show the public how to capitalize on the wonderful flexibility of high rated designs. Future Runs will doubtless discourage waste of power or conversion to dangerous speeds.

The oil industry has something at stake, too. It believes, generally, that it is good business to discourage waste of petroleum resources. If the average mileage of U.S. cars were raised just one mile per gallon, the annual saving would be 1,800,000,000 gal, valued at approximately $375,000,000, based on average service station prices without tax. (Paper, "The Economy Run Par for Gasoline Mileage," was presented at SAE Annual Meeting, Detroit, Jan. 16, 1953. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers).

A Correction

TWO numbers were reversed in the article, "Engineering Highlights of 1953 Passenger Cars," by W. S. James, which appeared in the April issue.

On page 58, under the heading, "Valve Gear—Valve-Seat Angles," the second sentence should read, "The preference for the 45-deg valve-seat angle on the exhaust valve is very evident and the use of the 30-deg angle on the inlet is, in all probability, with the hope of obtaining higher volumetric flow through the valve."

In addition, the "30 Deg" and "45 Deg" headings in the table that follows should be reversed, so that the "45 Deg" heads the column with the higher values and the "30 Deg" heads the column with the lower values.

TITANIUM—Today

This is the second installment of a two-part article. Part 1—Today appeared in the May issue of SAE Journal.

BETTER titanium alloys for the future will undoubtedly result from information now being developed on (1) equilibrium phase relationships of titanium with other metals, and (2) the kinetics of reactions in the solid state. Much information on these two subjects is already available and more is being obtained at the Armour Research Foundation and in various other laboratories, thanks largely to the far-sighted research programs of the Air Force and Army Ordnance.

The Phase Relationships

Most of the important binary phase diagrams and some of the ternary diagrams of titanium either have been or are in the process of being determined. As the ternary phase relationships can be generally quantitatively predicted from the binary diagrams, knowledge of the binary systems is of prime importance. The three basic types of solid-state phase relationships obtained in binary titanium-base alloys are differentiated principally by the effect the addition element has on either raising or lowering the transformation temperature (885 C) of the pure metal, and the phase changes which immediately follow at the high-titanium end of the systems. Above 885 C, the beta phase (body centered cubic) is at equilibrium. Below that temperature the alpha phase (hexagonal close packed) exists.

The first type of system is represented by Fig. 1. The binary systems of titanium with molybdenum, columbium, vanadium, and tantalum are known to belong to this group. This phase diagram is characterized by a continuous series of beta solid solutions with the formation of an alpha-plus-beta field which grows wider with decreasing temperatures. The photomicrographs included in the fig-

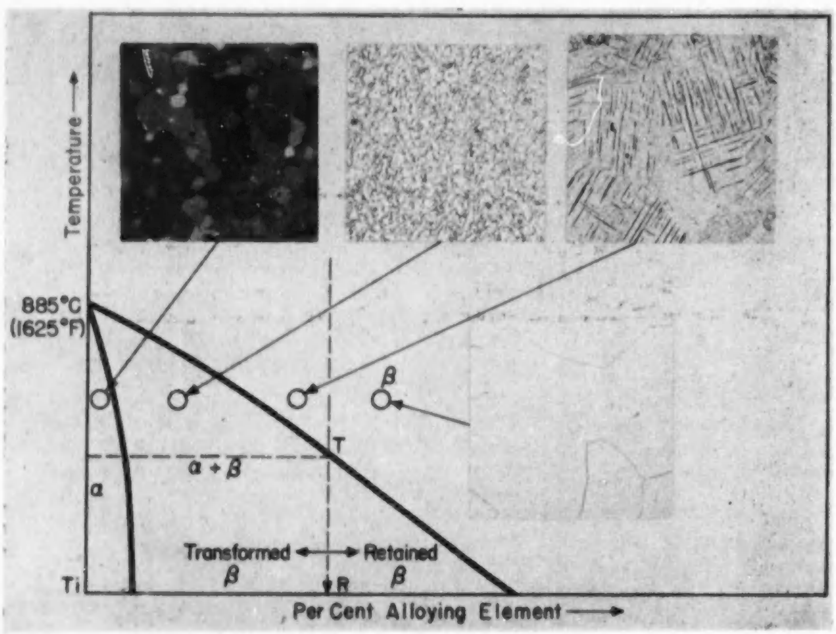


Fig. 1—Solid-state equilibria for the Type 1 binary titanium-base alloy systems showing typical microstructures of the various phase fields

and Tomorrow

Part II—Tomorrow

ure illustrate the structural appearance of the various phase fields. It should be noted that the structure of the two alloys quenched from the beta field is different. The structure of the alloy to the left of the broken vertical line, *R*, shows acicular transformed beta, generally known as alpha prime; whereas the structure of the alloy to the right of *R* consists entirely of retained beta. In the former case the supersaturated beta phase partially decomposed to give alpha prime, which, similarly to the martensite of steels, is formed by a diffusionless transformation. X-ray examination shows this nonequilibrium product is a distorted version of alpha, apparently of the same composition as the beta solid solution from which it is formed. All alloys quenched from the beta field to the left of *R* will have structures showing alpha prime. Also, all alloys heat-treated in the alpha-plus-beta field at temperatures above *T* will consist of isothermal alpha plus alpha prime. Alloys heat-treated below *T* in the alpha-plus-beta field will consist of alpha plus retained beta.

The second type of system, represented in Fig. 2, is typical of the binary systems of titanium with chromium, iron, silicon, nickel, copper, and hydrogen. For most practical purposes this type of system is similar to that of Fig. 1 and similar structural features are noted. However, below the eutectoid temperature the beta phase decomposes into alpha plus an intermediate phase, gamma. In most alloys of these systems the eutectoid reaction is of little practical importance, as it does not occur within the period of practical heat-treatment. The eutectoid reaction must be considered, however, if the alloys are to be exposed to elevated temperatures for long periods.

The third type of phase diagram is shown in Fig. 3. The known members of this group are the binary systems of titanium with aluminum, oxygen, nitrogen, and carbon. Whereas the first three members of this group show extensive solubility of the addition element in alpha titanium, the maximum solubility of carbon is less than 0.5%. Aluminum, the only metal in this group, is also the only member showing substitutional solubility; oxygen, nitrogen, and carbon being interstitially soluble in titanium. The major characteristic of

THIS is Part II of a two-part article based on:

The Bases for Tonnage Titanium Production
by C. I. Bradford
Rem-Cru Titanium, Inc.

Titanium Alloys for Aircraft Engine Forgings
by L. R. Frazier
General Electric Co.

Titanium Alloy Development
by M. Hansen and H. D. Kessler
Armour Research Foundation

Titanium in Airframes
by F. R. Kostoch
North American Aviation, Inc.

Utilization of Titanium and other Alloys in Corrosive Environments
by W. L. Williams
U.S. Naval Engineering Experiment Station

Part II is based chiefly on the papers by Hansen and Kessler, and Williams.

All five papers were presented at a symposium at the SAE Annual Meeting, Detroit, January 16, 1953. They are available separately in multilithographed form from SAE Special Publications Department at 25¢ each to members and 50¢ each to nonmembers.

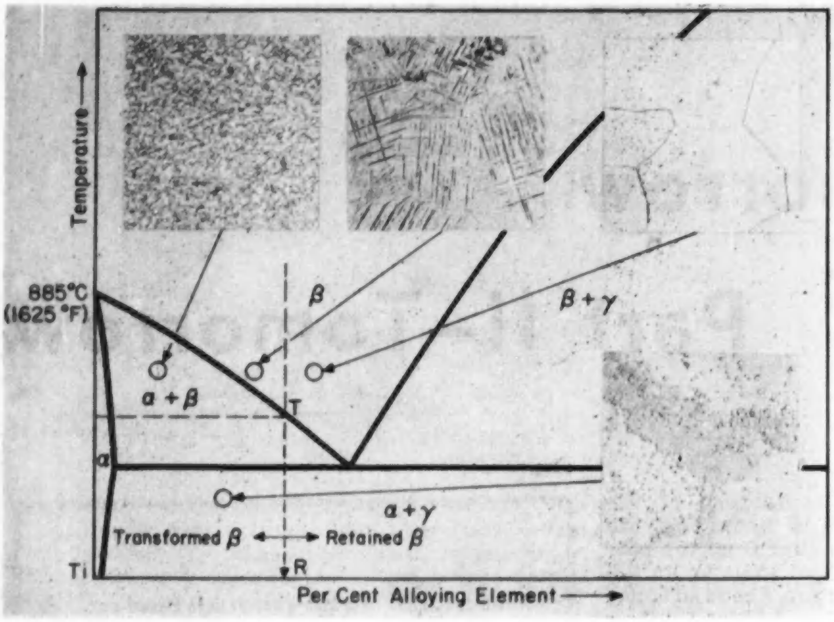


Fig. 2—Solid-state equilibria for the Type 2 binary titanium-base alloy systems showing typical microstructures of the various phase fields

this type of system is that the addition element raises the transformation temperature of titanium and thereby stabilizes the alpha phase to higher temperatures. As noted in the photomicrographs, which are only typical of titanium-aluminum alloys, the beta phase is not retained, regardless of composition, on quenching from the beta field. In the titanium-aluminum system the serrated type of transformation product shown is produced on quenching; whereas in the oxygen, nitrogen, and carbon alloys an acicular product is obtained on similar heat-treatment.

The Transformation Characteristics

The key to understanding the heat-treating principles in titanium-base alloys lies in recognizing that the same solid-state reactions occur which are basic to established commercial ferrous and nonferrous alloys. Response to heat-treatment

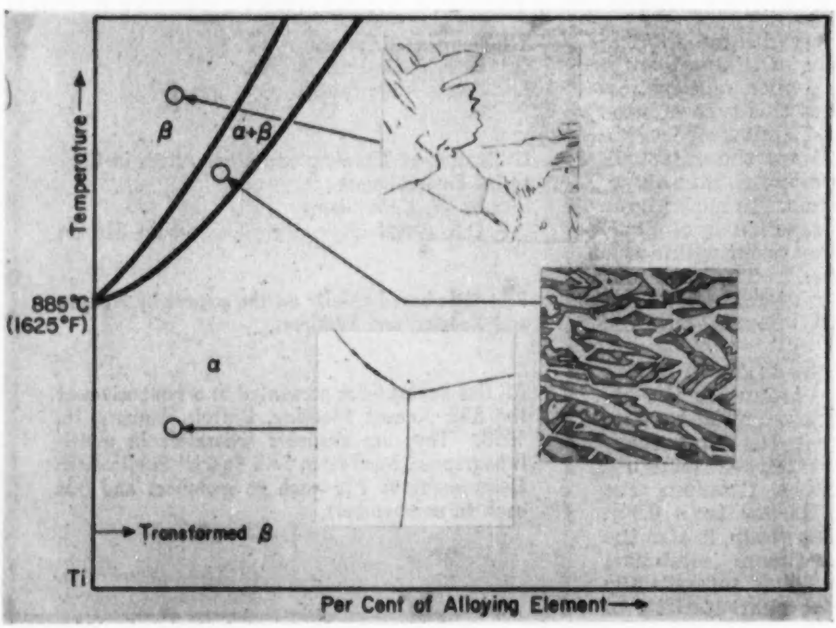


Fig. 3—Solid-state equilibria for the Type 3 binary titanium-base alloy systems showing typical microstructures of the various phase fields for titanium-aluminum alloys

results from the instability of a high-temperature phase at lower temperatures. This instability can manifest itself in three possible ways, depending upon the alloy system and composition: (1) by precipitation of a new phase from supersaturated beta; (2) by the eutectoid decomposition of beta to two new phases; and (3) by transformation to some metastable structure such as alpha prime. One or more of these reactions can be recognized and utilized in each of the heat-treatable titanium alloys.

Fig. 4 shows schematic hardness versus composition curves for two types of binary titanium-base alloys. The two diagrams illustrate the hardness changes which can be produced by various heat-treatments of the Type 1 and Type 2 phase diagram groups. The upper curve shown for the titanium-molybdenum type system indicates that very little hardness increase can be expected by water quenching from the beta field. The peak that occurs at low alloy contents represents only a small hardness increase with respect to the "annealed curve." This small hardness increase can be attributed to the formation of alpha prime, indicating that this martensitic product is relatively soft. To the right of the quenching peak, increasingly greater amounts of soft retained beta coexist with alpha prime to the composition *R*, where the minimum hardness occurs and the structure consists entirely of retained beta. The heat treatability of this group of alloys is entirely dependent on the rejec-

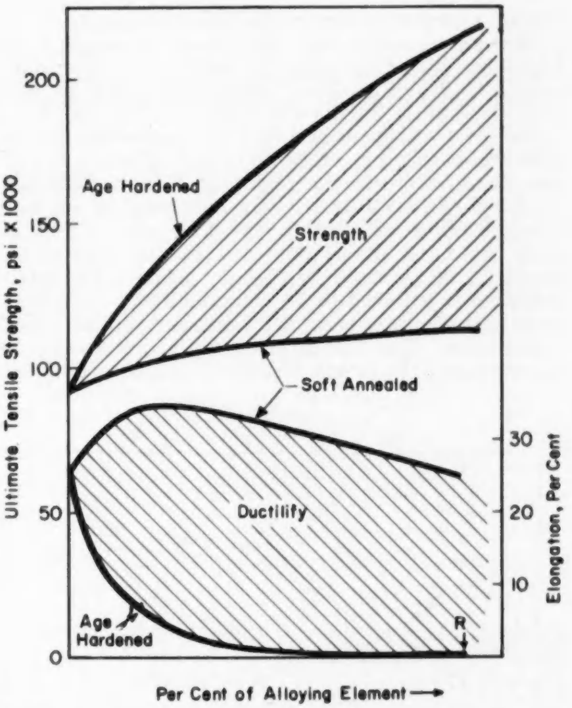


Fig. 5—Tensile properties versus alloy content illustrating the range of properties obtainable by heat-treatment for either the Type 1 or the Type 2 alloy systems

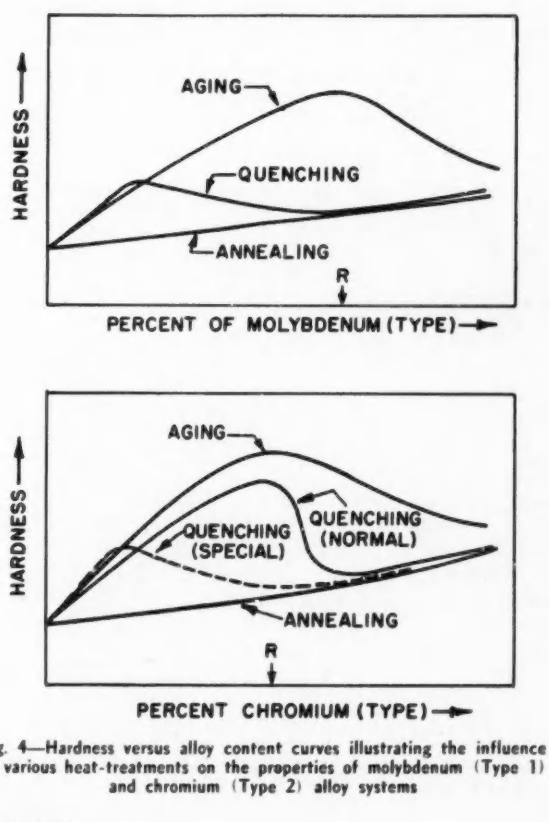


Fig. 4—Hardness versus alloy content curves illustrating the influence of various heat-treatments on the properties of molybdenum (Type 1) and chromium (Type 2) alloy systems

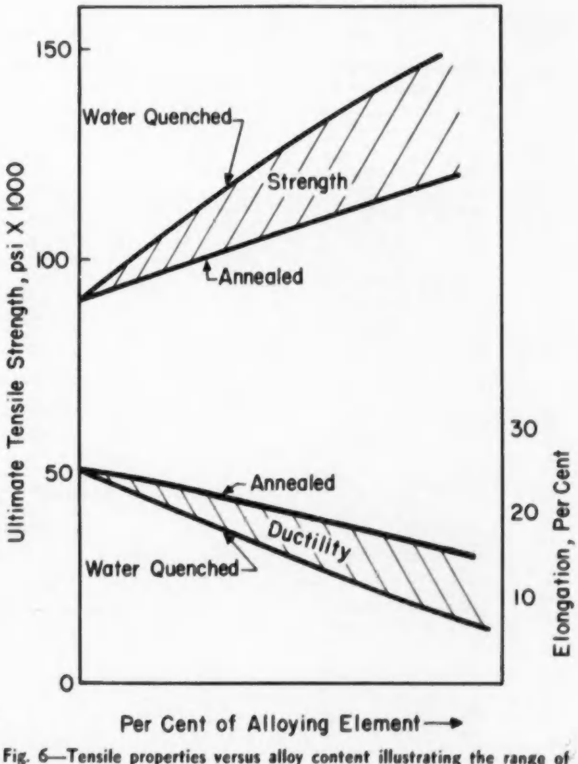


Fig. 6—Tensile properties versus alloy content illustrating the range of properties obtainable by heat-treatment for the Type 3 alloy system, titanium-aluminum

tion of alpha from the metastable beta phase. To obtain an optimum combination of strength and ductility, either quench-and-age or isothermal-quench-and-age types of treatments could be applied depending on the composition of the alloy.

The lower diagram of Fig. 4 shows that on water quenching titanium-chromium type alloys, a hardness peak occurs in the region of *R*, and that this hardness can be only slightly increased by an additional aging treatment. For the sake of definition, the hard phase obtained at the quenching peak will be referred to as beta prime. The high hardness is believed to be associated with the precipitation of alpha from the normally soft retained beta phase. The fact that no alpha precipitate is observed in beta prime structures, as the equiaxed grains appear identical to soft retained beta, indicates that the high hardness may result from a preprecipitation phenomenon of some sort. In the titanium-chromium system, the normal water-quenching process is not sufficiently drastic to suppress the preprecipitation reaction. In some recent work at the Armour Research Foundation, only by a drastic quench in iced brine was it possible to suppress the beta prime reaction. The broken curve in Fig. 4 illustrates the results. Similar experiments performed with equally small samples of titanium-chromium alloys based on magnesium-reduced titanium gave only the hard beta prime structure, indicating that contamination by the interstitially soluble elements increases the rate at which beta prime is formed.

By step quenching, beta prime has also been observed to occur in the titanium-molybdenum system, as preceding the appearance of precipitated alpha phase. On the basis of these results it would appear that differences in the heat-treatment between the titanium-molybdenum and titanium-chromium alloys are due to variations in reaction rates rather than the actual mechanism of hardening.

Fig. 5 shows the range of tensile properties possible for the Type 1 and Type 2 alloys. The degree of heat-treatability increases considerably with increasing alloy content to the composition *R*. The maximum strengths are obtained by age hardening; however, the higher strengths are accompanied by very poor ductility values. One of the main objects of the present research on the transformation kinetics of titanium-base alloys is the determination of the particular type of heat-treatment which will give the best combination of tensile strength and ductility.

Fig. 6 illustrates the range of tensile properties

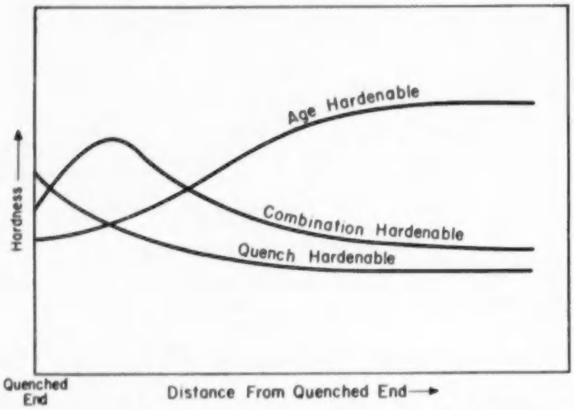


Fig. 7—Schematic representation of the types of hardenability curves obtainable in titanium alloy systems

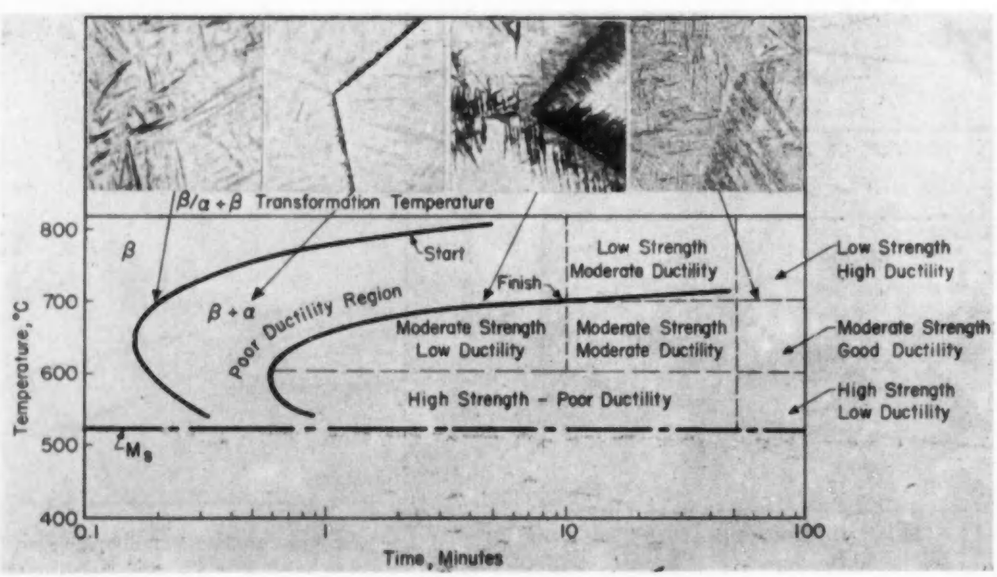


Fig. 8—TTT diagram for a 7% molybdenum alloy illustrating the range of properties and microstructures obtained during the course of isothermal heat-treatment

possible in titanium-aluminum alloys. As yet there is no information available on the heat-treatability of the other binary alloys of this phase diagram group. As shown in Fig. 6, titanium-aluminum alloys can be hardened somewhat by water quenching. The process by which this hardness increase occurs is not yet fully understood. In general, there is a moderate strength increase with increasing aluminum content, and a commensurate loss in ductility.

Jominy Tests Used

By use of a tool popular among ferrous metallurgists, it has been found that a standard Jominy end-quench test is very useful in giving a broad picture of transformation structures and hardnesses with progressively slower cooling rates. (See Fig. 7.) The various types of hardening processes can be detected by the end-quench procedure. A quench-hardenable alloy in which alpha prime is the only contributor to hardness gives a curve similar to that obtained for steels and shows the highest hardness at the quenched end. An alloy in the region of the composition of *R* (Fig. 4), which hardens only by aging, gives a curve having a hardness minimum at the quenched end. Alloys of intermediate compositions, between the alpha prime and aging peaks, show a hardness maximum a short distance from the quenched end.

Isothermal transformation studies are of considerable value in evaluating the heat-treating characteristics of titanium alloys. A time-temperature-transformation (TTT) chart for a 7% molybdenum alloy is shown in Fig. 8. Tensile property trends indicated in the diagram are based on unpublished work being done at the Armour Research Foundation and illustrate the useful information obtainable with this type of study. Typical structures obtained for various holding times at one temperature level are shown above the diagram. The results of tensile tests run on the isothermally transformed 7% molybdenum alloy are shown in Table 1.

Alloys treated in the region between the two C

Table 1—Tensile Properties of Isothermally Transformed 7% Molybdenum Titanium-Base Alloys

Heat-Treatment: Temperature, C	Heat-Treatment: Time, min.	Ultimate Tensile Strength, psi	Reduction in Area, %	Elongation, %
550	5	178,000	0	0
	15	179,000	3	1.5
	60	180,000	2	1.5
600	15	176,000	2.5	0
	60	173,000	3	1.5
	120	166,000	5	3
650	5	165,000	5	1.5
	15	144,000	11	6
	60	140,000	12	6
700	5	131,000	8	5
	15	122,000	16	6
	60	127,000	24	12
750	5	122,000	5	3
	15	130,000	9	9
	60	109,000	18	19

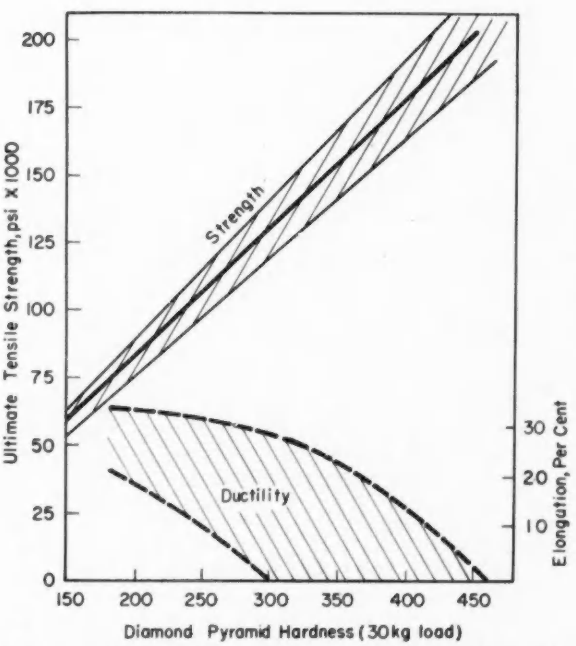


Fig. 9—Tensile properties versus hardness correlation which generally applies to all titanium alloys, illustrating the spread in tensile values obtainable at a given hardness value

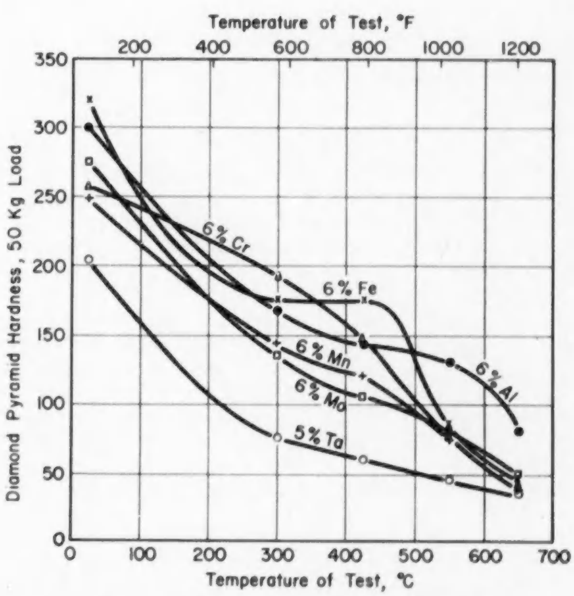


Fig. 10—Hardness versus temperature curves illustrating the comparative hot hardness of various binary titanium-base alloys

curves—that is, between the start and completion of alpha precipitation—are generally quite brittle. Alloys treated below the nose of the C curve generally possess very high strengths, but are characteristically of very poor ductility. At all temperatures ductility improves with increasing isothermal annealing times. For this particular alloy the best combination of strength and ductility is obtained on heat-treating between 650 and 700 C. The best ductility and lowest strength values are obtained by heat-treating for an hour or longer at temperatures above 700 C and the beta/alpha plus beta transformation temperature indicated by the upper horizontal lines at 820 C. The lower horizontal line represents the Ms temperature below which alpha prime forms on quenching from the beta field.

Development of Titanium Alloys for Use at Elevated Temperatures

The excellent strength-to-weight ratio obtainable with titanium and its alloys offers great promise for aircraft applications, particularly where somewhat elevated temperatures are encountered. Recognizing this fact, the Wright Air Development Center is sponsoring an investigation on "The Development of Titanium Alloys for Use at Elevated Temperatures" at the Armour Research Foundation. Of particular interest are alloys which can be substituted for aluminum alloys and stainless steel parts in the gas turbine.

The first step in Armour's development of heat-resistant titanium alloys was the selection of a stable, high-strength, single-phase matrix. Subsequent work was then directed toward increasing the resistance to creep and improving the strength by the addition of other elements.

The alloys, no matter how simple or complex in composition, must be stable structurally at the temperature of service or at lower temperatures. This requirement follows from the need for the structurally sensitive mechanical properties not to change in a way that would be detrimental to service life. Ideally, no precipitation or eutectoid decomposition should take place in the temperature range of the application. Such structural changes may result in a substantial variation of mechanical properties, and would cause volume changes which could be detrimental to the application. Heat-treatments should be applied with the primary object of achieving structural stability and a maximum resistance to creep.

Knowledge of many of the binary phase diagrams played an important part in the selection of alloys for the initial Armour studies. Particular attention was focused on the titanium-aluminum system, as the phase diagram indicated that these alloys would be stable over a wide range of compositions due to the extensive solubility of aluminum in alpha titanium.

Although knowledge of the phase relationships considerably reduced the number of alloys required for the initial studies, the volume of alloys was still great; therefore a good screening technique was required. The hot hardness test was selected; for, as shown in Fig. 9, there is a good correlation between hardness and strength, but ductility can vary

Titanium Resists

TITANIUM belongs well toward the noble-metal end of the galvanic series—which means that it resists galvanic corrosion well. This is one of its great advantages as an engineering material.

Galvanic corrosion, as it is defined in a publication of the International Nickel Co., is the faster-than-normal corrosion of a metal which takes place when these two conditions exist: (1) Two metals of differing nobility (resistance to chemical action) are in electrical contact. (2) Both are submerged in an electrolyte. The less noble metal corrodes more rapidly than it would if placed in the solution by itself. Also, the greater the difference in nobility of the two metals, the stronger is the tendency for galvanic corrosion to occur. Finally, the more noble metal usually corrodes more slowly than it would if placed in the solution by itself.

The accompanying table lists various engineering materials in galvanic-series order. Data for the table were obtained by measuring the open circuit potentials in turbulent sea water, flowing at a velocity of 13 fps, and at a water temperature of 77 F. They represent steady state potentials, since in most cases the measurements were made 14 days after exposure, thus allowing time for surface conditions to approach equilibrium.

The table is not infallible because the potentials were determined under a single set of environmental conditions. However, the metals in this galvanic series maintain roughly the same relationship in many other environments.

The following simple rules can help the practical engineer to remedy bad corrosion situations or head off troubles before they develop:

1. *Select combinations of metals as close together as possible in the galvanic series* listed in the table. For example, titanium and Type 304 stainless would work well together, but the coupling of titanium and aluminum could lead to disastrous effects on the latter material.

2. *Avoid making combinations where the area of the less noble material is relatively small.* For example, a joint failure would occur many times faster with copper rivets

Galvanic Corrosion Well . . .

in titanium plates than it would with titanium rivets in copper plates.

3. *Insulate dissimilar metals wherever practical.* If complete insulation is not practical, it will be helpful to use paint or plastic coatings at joints if the circuit resistance can thereby be increased appreciably.

4. *Apply coatings on exposed surfaces with caution.* For example, do not paint the less noble material without also painting the more noble metal. Otherwise, greatly accelerated local corrosion can occur by concentrating the galvanic current at coating imperfections on the less noble metal. It follows that coatings should be kept in good repair.

5. *When dissimilar metals are located remote from one another, but are connected by an external conductor, design the equipment to keep the metals as far apart as possible.* The effect of this is to reduce galvanic current by increasing the resistance of the liquid path.

6. *If practical, add suitable chemical inhibitors to the corrosive solution.* Possibilities in this direction for the alleviation of galvanic attack have been described by G. B. Hatch in "Inhibition of Galvanic Attack of Steel with Phosphate Glasses" in Industrial and Engineering Chemistry, Vol. 44, No. 8, August, 1952, pages 1780–1786.

7. *Avoid joining dissimilar metals with threaded joints, if possible.* Threads are likely to deteriorate rapidly. Brazed joints, made with a brazing alloy more noble than at least one of the metals to be joined, are preferred.

8. *Provide protective galvanic current, either from an external power source or from zinc, magnesium, or steel consumable anodes installed within the system.* These methods have been described in detail by, among others, L. P. Sudrabin and H. C. Marks in "Cathodic Protection of Steel in Contact with Water" in Industrial and Engineering Chemistry, Vol. 44, No. 8, August, 1952, pages 1786–1791; and by T. E. Nicholas in "Cathodic Engineering Preview" in Chemical Engineering, Vol. 59, No. 7, July, 1952, pages 220–221.

9. *Install replaceable waster pieces.* If galvanic corrosion cannot be prevented, it is often possible to install a section of less noble material at the joints where galvanic contact occurs. Thus, nearly all attack is localized and restricted to the replaceable item. For example, heavy wall steel nipples could be used between steel tubes and noble metal fittings in a piping system.

Table—A galvanic series based on potential measurements in sea water flowing at 13 fps and at a temperature of 77 F (After F. L. LaQue of International Nickel Co., slightly edited.)

Metal	Potential negative to saturated calomel half cell, volts
Anodic End	
Zinc	1.03
Aluminum (Alclad 3S)	0.94
Aluminum 3S-H	0.79
Aluminum 61S-T	0.76
Aluminum 52S-H	0.74
Cast iron	0.61
Carbon steel	0.61
[a] Stainless 430 (active)	0.57
Ni-Resist cast iron, 20% Ni	0.54
[a] Stainless 304 (active)	0.53
[a] Stainless 410 (active)	0.52
Ni-Resist cast iron, 30% Ni	0.49
Ni-Resist cast iron, 20% Ni & Cu	0.46
Naval brass	0.40
Yellow brass	0.36
Copper	0.36
Red brass	0.33
Composition G bronze	0.31
Admiralty brass	0.29
90-10 Cu-Ni, 0.8% Fe	0.28
70-30 Cu-Ni, 0.5% Fe	0.25
[a] Stainless 430 (passive)	0.22
Nickel	0.20
[a] Stainless 316 (active)	0.18
Inconel	0.17
[a] Stainless 410 (passive)	0.15
TITANIUM, commercial	0.15
Silver	0.13
TITANIUM, high purity iodide	0.10
[a] Stainless 304 (passive)	0.08
Hastelloy C	0.08
Monel	0.08
[a] Stainless 316 (passive)	0.05
Cathodic End	

[a] The stainless steels exhibited erratic potentials depending on the incidence of pitting and corrosion in the crevices around specimen supports. The values listed represent the observed extremes and should not be considered as establishing invariable potential relationships among the alloys covered.

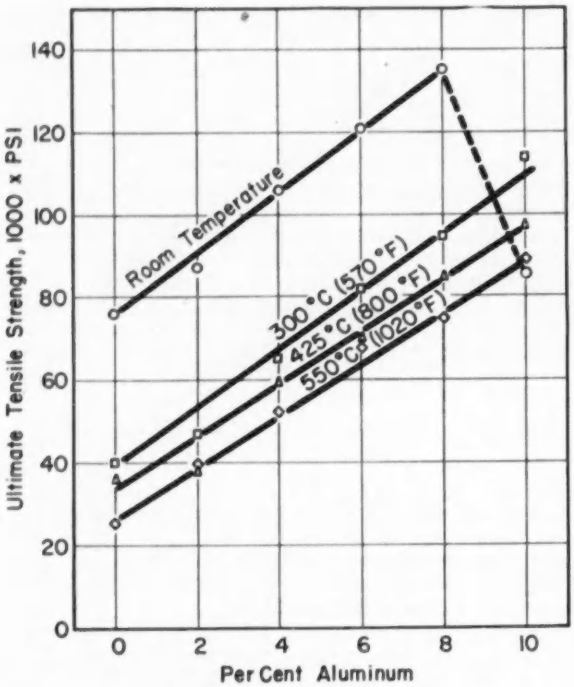


Fig. 11—Tensile strength versus aluminum content at various temperature levels for titanium-aluminum binary alloys

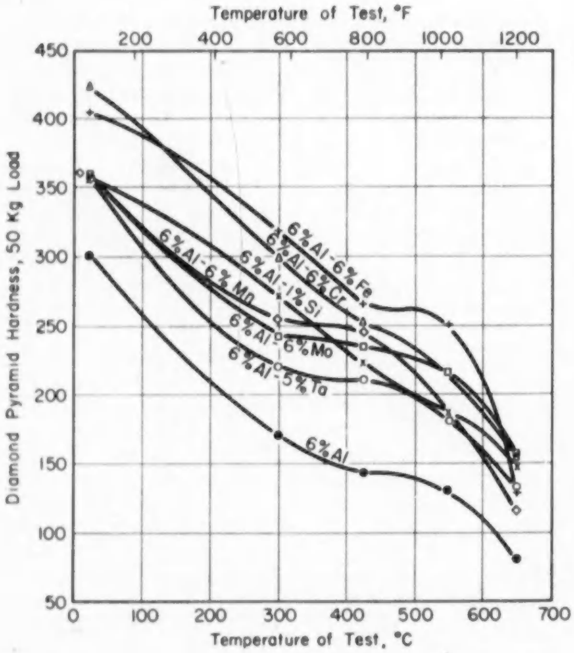


Fig. 12—Hardness versus temperature curves illustrating the hot hardness of various ternary alloys based on the titanium-aluminum system, as compared to the 6% aluminum binary alloy

considerably for a particular hardness level. Although the data used in the preparation of Fig. 9 were based on room-temperature tests, the results of hot-hardness and elevated-temperature tensile tests have indicated that the hot hardness and hot strengths fall on the same curve.

Fig. 10 shows the results of hot-hardness tests carried out on binary alloys containing 5 and 6% additions of various elements. Based on these results and much additional data not shown here, the titanium-aluminum system was selected as the stable, high-strength base for the ternary alloy studies. As shown in Fig. 10, the 6% aluminum alloy showed the best stability at temperatures above 400 C. The strength-composition relationships for titanium-aluminum alloys at elevated temperatures are presented in Fig. 11. Although the strength increases with increasing aluminum content, compositions of 10% or more aluminum are extremely brittle at room temperature; therefore, 8% was selected as the maximum aluminum content for subsequent alloy development studies.

The selection of ternary alloys based on the titanium-aluminum system was considerably simplified by the availability of the binary phase diagram information. Systems where precipitation hardening could be expected were selected for this portion of the investigation. The hot-hardness test was again used for the initial screening. An example of the results is shown in Fig. 12, which presents data for alloys containing 6% aluminum and the additions of from 1 to 6% of other elements. It will be noted that considerable improvement is obtained in hot hardness by the addition of other elements to the 6% aluminum base. The results of the hot-hardness studies of ternary alloys based on titanium-aluminum indicated that additions of iron, chromium, molybdenum, and silicon were of prime interest. Further studies were then carried on using creep rupture testing as a basis for evaluation of the more promising alloys.

Structures Are Complex

With the exception of the titanium-aluminum alloys, many of the binary and ternary alloys studied at Armour had complex structures consisting of two or three phases at the temperature of testing. As noted previously, properties of the binary alloys of the titanium-chromium and titanium-molybdenum type systems can vary within wide limits of strength and ductility. Similarly, many of the Ti-Al-X alloys investigated were heat treatable within wide limits of properties by the process of the precipitation of alpha or gamma from the supersaturated beta phase. Using the known transformation characteristics of typical alloys, it was possible to predict heat-treatments which would render both the binary and the ternary alloys structurally stable at the temperature of testing. Only by the application of such stabilization treatments was it possible to obtain a fair comparison of the elevated temperature properties of the various compositions tested.

Fig. 13 and Table 2 illustrate the creep rupture properties of some of the characteristic experimental alloys, as compared with the commercial alloys MST 3Al-5Cr (produced by the Mallory-

Sharon Corp. and tested at Armour Research Foundation) and Ti-150A (2.7% Cr, 1.3% Fe, 0.25% O). At 425 C (800 F), the experimental alloys are as good, if not better than, MST 3Al-5Cr. The curves lie considerably above that of commercially pure titanium. The results at 550 C (1020 F) show that the curves for the experimental alloys 8% aluminum-4% molybdenum, 8% aluminum, and 6% aluminum lie considerably above those for the two commercial alloys; and titanium does not even appear in the diagram.

Fig. 14 shows a comparison on a strength-weight basis between two experimental alloys and annealed Types 304 and 403 stainless steels at 540–550 C. These data certainly indicate that titanium-base alloys offer excellent properties for application to temperatures of at least 550 C (1020 F). At higher temperatures, oxidation becomes a problem with the present alloys, although aluminum has been shown to improve the oxidation resistance of commercial titanium. It is quite possible that if titanium-base alloys have good strength properties at even higher temperatures they could be applied, providing they are protectively coated or properly alloyed to prevent oxidation.

Titanium metallurgy is in the ideal position of developing concurrently or even in advance of industrial practice. The important physical metallurgical information on phase diagrams and transformation kinetics is of considerable aid to alloy development and should help to bring about the development of optimum alloys for various applications in the shortest possible time. Use of this approach has resulted in the development of titanium-base alloys having excellent properties at temperatures up to 550 C (1020 F). Some of these alloys show better creep rupture properties at this temperature than types 304 and 403 stainless steel.

Table 2—Creep Rupture Test Results for Alloys Tested at 425 C (800 F) and 550 C (1020 F)

Alloy Composition and Heat-Treatment	Testing Temperature, C	Tensile Stress, psi	Time to Rupture, hr	Total Elongation, %	Stress to Rupture 100 hr	Stress to Rupture 500 hr
6% Al	425	80,000	0.58	13	79,500	78,000
(650 C-1 hr)		79,500	91	22		
		79,000	288	20		
	550	58,000	0.25	23	32,000	26,000
		53,000	1.5	30		
		35,000	49	36		
8% Al	425	87,500	21	14	86,500	84,000
(650 C-1 hr)		86,000	183	6		
		83,000	270	17		
	550	77,500	0.40	19	45,000	38,000
		75,000	0.67	8		
		62,500	5.3	9		
		45,000	102	9		
8% Al-4% Mo	425	110,000	4.7	14	105,500	102,000
(1050-1 hr-		108,500	48	5		
F.C. → 700		107,000	83	5		
C-24 hr)		106,000	87	14		
		103,000	360	5		
	550	84,800	3.5	13	56,000	45,500
		65,000	33	9		
		50,000	181	5		
3% Al-5% Cr	425	81,500	60	11	80,500	77,000
(Mallory-		80,000	137	8		
Sharon Alloy)	550	80,000	0.08	..	19,000	12,000
(1000 C-1 hr		52,800	3.0	36		
-F.C. → 600		22,000	64	14		
C-24 hr)						
304 (Annealed)	540	..			36,500	33,000
403 (Annealed)	540	..			32,000	31,000

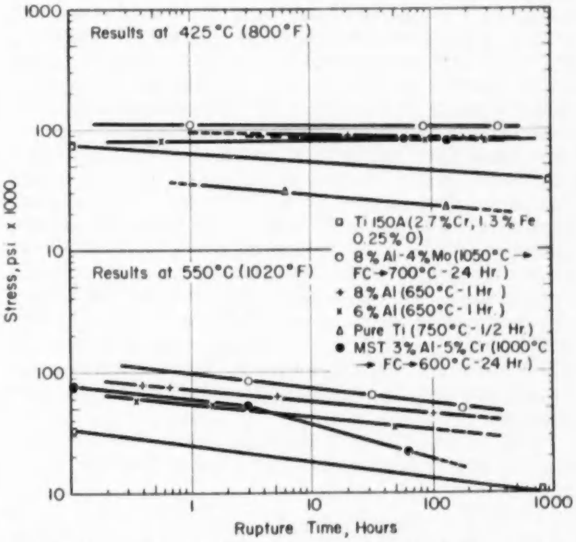


Fig. 13—Creep rupture test results at 425 and 550 C showing the comparison of properties between several experimental alloys, commercially pure titanium, and two commercial titanium-base alloys

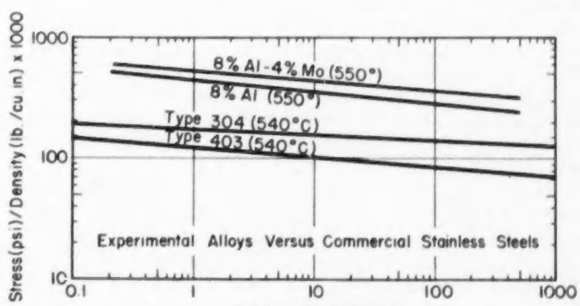


Fig. 14—Creep rupture test results showing the comparison on a strength-weight basis between two experimental alloys and two commercial stainless steels tested at 550 and 540 C, respectively

Manufacturing Costs

CONTROL systems now being used were revealed to be generally similar in concept but differing in detail. Most systems established a goal or target to work toward and a means of measuring progress toward attainment of that goal. Summary information provided to management enables them to control the cost of their products by taking corrective steps in areas not attaining the goals. Although the end result of cost control systems is generally intended to be the same, a wide variance is recognized in the methods used to determine goals or measures, and the degree of control application. The methods and degree of control vary with different company policies, contractual quantities involved, size of the plants, and techniques employed.

Unanimously accepted as an overall control principle was the practice of gradually reducing the planned direct hours per ship during the life of the contract. This is based on historical data, which show that, as the work progresses, most difficulties inherent in the early stages of a contract are overcome—tooling is improved and made more complete; certain methods and layouts found to be inefficient are corrected; engineering changes normally reduce; the increased rate of production reduces the setup time; and jobs are broken down finer so as to enable workers to become more proficient on a specific job.

Most of the panel comments stem from experience in the airframe section of the industry.

Direct Labor Performance

In most plants, the groups performing the functions of plant layout, time study, and personnel loading report to one head, who, in turn, is responsible in most cases to the overall plant manager. Exception to this was noted in one company, where the control function was vested in the manufacturing division and reported to the manager of that division. The opinion was expressed that the type of organization for cost control was not particularly significant, as long as teamwork and cooperation were the order of the day between departments and groups.

Most organizations seem to have a "pad" between the contract price and the direct labor goal on a renegotiable contract. This pad usually exists primarily to safeguard the accomplishment of the objective as well as to try to better the goal, if possible.

The accepted method of estimating goals for new models was reported to be the use of hours per pound historical data adjusted for the particular rate, quantity, and complexity of the model under consideration. One must realize, however, that present historical hours per pound data now used for estimating may become obsolete with the introduction of new materials, higher performance characteristics, and radical configuration changes of future ships.

It was generally agreed that reports should be issued as soon as possible after the close of the work period, to be of control value. Elapsed time for weekly reporting varied from 24 hr to several days. A tendency was noted for hand-tabulated reports to be issued more nearly currently than those requiring machine tabulations, possibly because distribution cards are used first for payroll purposes before running manufacturing reports. To reduce the elapsed time in reporting, it was suggested that reports be prepared for a separate group of departments each day instead of all at the weekend, so that the reporting workload could be more evenly distributed.

A discussion developed on the degree of cost breakdown necessary for control purposes. In detail fabricating departments, the degree of breakdown in some companies was the individual part; another company used the individual worker; and in one instance the assistant foreman's group was felt to be sufficient. It was evident that the degree of control applied by one company under a particular set of circumstances would not necessarily apply to the different conditions prevalent in other plants. The degree of breakdown in detail fabricating departments was not influenced by production rates. On assembly operations, however, it was agreed that work should be broken down more finely on the higher rate programs. Depending upon the rate, degree of control varied from single small subassembles to major sections of the airplane.

As a rule, data on number of units completed was said to be difficult to get correctly and on time. In major and final assembly departments, completions are reported by individual ship numbers—in detail departments by the number of parts completed. Since the efficiency of a department depends upon the amount of work shown to have been completed, the importance of accurate reporting was emphasized. It was noted that the reponsibility for reporting the per cent complete of partially completed work was vested, in most cases, in the production departments; in one case the inspection department was the agency.

The majority of companies represented did not report cost control performance by shift, for the opinion was expressed that the only advantage would be to instill competition between shifts. Cer-

Can Be Reduced

John Gronemeyer, North American Aviation, Inc.

Secretary's report of Panel on Manufacturing Cost Control held as part of the Aircraft Production Forum at the SAE National Aeronautic Meeting, Oct. 1, 1952. Leader was W. F. Snelling, North American Aviation, Inc.; Coleader was Herbert Caldwell, Lockheed Aircraft Corp.

tain disadvantages were pointed out that could result from controls by shift, such as the difficulty of measuring partially completed work, and the possible incentive for the shop to show greater accomplishment by working off the easiest jobs first but in so doing not following the proper priority sequence.

Time Study

Time studies were unanimously endorsed as an aid in the reduction of manufacturing costs. Advantageous results of time studies were cited to be the establishment of the best work method, improvement of tooling where justified, redesign of parts and assemblies to facilitate production, refinement of work flow and layout, and the establishment of performance goals against which progress could be measured. There were differences of opinion as to the basis of the standard. Some used the average worker, others, the best. In either case, it was agreed that continuous reduction of time per unit produced was expected. Continuous improvement could be introduced through the use of factors, to adjust the time standard for the anticipated realization at specific accumulative ships. This method provides the shop with a comparison of current actual hours to current standard hours, as well as to the time study value.

Application of synthetic time standards to the fabrication of detail parts was stressed as fundamental in setting the best and most reliable standards. Use of synthetic standards, it was felt, not only eliminates the possible variance in time studies introduced by different raters, but provides a goal that is based on wider industrial experience. Jobs that exceed the standard are checked by time study men to point up the necessary action to meet the goal.

It was emphasized that time studies must, above all, be fair and have complete acceptance by shop personnel. To accomplish this result, in one instance, the practice of training shop supervision and leadmen to make and set their own standards with time study methods was used. Although most time study work seems to be performed by industrial time study engineers, all agreed that the training of shop personnel to participate actively was an excellent plan.

Use of Machine Tabulating in Preparing Reports

A wide and varied use of machine tabulating was described for the preparation of reports. Degree of application varied from completely tabulated systems starting with engineering release and ending with the billing for the completed article, to a more selective use. General applications enumerated were: obtaining status information on tools, production parts, and assemblies; preparation of shop orders; projection of labor loads; comparison of standard against actual hours expended; tally and

Members of the Manufacturing Cost Control Panel were (left to right): Secretary John Gronemeyer, North American Aviation, Inc.; Paul Athans, Consolidated Vultee Aircraft Corp.; Herbert Hall, Douglas Aircraft Co., Inc.; Fred Neale, Boeing Airplane Co.; Panel Coleader Herbert Caldwell, Lockheed Aircraft Corp.; J. C. Mabe, Douglas Aircraft Co., Inc.; Panel Leader W. F. Snelling, North American Aviation, Inc.

distribution of delinquency lists; and compilation of historical data for evaluation and estimating use.

Prime limitation in most companies on the use of tabulating equipment for manufacturing cost control appeared to be the already heavy tabulating load imposed by financial needs to get out the payroll and other accounting reports. Those concerns having separate tabulating equipment for manufacturing department use generally reported greater usage and more timely preparation of reports. It was brought up that the separation of the manufacturing tabulating function from financial was desirable because financial people were not always completely familiar with manufacturing operations. A suggested solution of this problem was to develop tab machine experts with the know-how of manufacturing organization and systems. Another possibility suggested was setting aside the second shift for all manufacturing tab runs.

The use of tab machines was said to be ideally suited to those cases where the distribution cards could be used for more than one purpose.

Detail Lot Size

It was pointed out that most lot sizes at present average about twice the monthly assembly rate.

The determination of lot quantity involves the weighing of those costs which *decrease* as the lot size increases against those costs which *increase*. Costs cited as decreasing with larger lot size were setup and work preparation, work order and parts handling, planning, material inventory deletion, and warehouse handling. Cost increasing with greater lot quantity were storage facilities, work in progress, and obsolescence due to engineering changes.

It was emphasized that careful selection of the optimum detail lot quantity by proper evaluation of the particular variable costs involved would result in substantial manufacturing savings. It was noted that the degree of possible savings was often affected by the limitation of material availability, machine or processing capacity, and the problem of keeping a level labor load in the shop.

One company related a plan used for reducing setup costs. This company surveyed their list of parts to be fabricated and selected those parts having a common setup operation. These parts were then grouped and fabricated at one time in order to gain the advantage of only one setup.

Overhead Control

Two steps were emphasized for controlling supporting labor expenditures. First step was to break down the costs by responsibility in sufficient detail to permit proper evaluation of the expenditures. Initial breakdown is usually by department and then by classification of work performed within the department.

After a system has been established for determining where the money is being spent, the second step is to establish cost control objectives against which the actual expenditures can be measured. For the most part, it was indicated that supporting labor cost goals were established from comparative ratios to direct labor dollar costs. Some application of time study was also noted in setting measurement standards in the production control function for work order and parts handling, along with certain maintenance operations. It was said, however, that strides have yet to be taken to develop convenient measuring sticks for overhead labor that are as effective as the controls commonly in use for direct labor. Measurements for overhead labor are, no doubt, more difficult.

Although the administering of a ratio system provides a means of control within a predetermined ratio, it was observed that the use of ratios can result in greater than warranted overhead costs when direct labor is overexpended, as well as the possibility of excessive direct costs because of insufficient overhead support. Elimination of ratios and the substitution of total overall cost per pound or cost per ship was propounded as a potentially better founded approach.

Control of nonproductive materials costs was discussed as another major category of overhead costs. Nonproductive materials were broadly defined as those materials which do not become part of the airplane. Stationery, perishable tooling, rags, cutting oils, safety goggles, and other comparable items comprise this category. It was indicated that most of the cost reduction effort to date in this category has been to compile and publicize these expenditures in sufficient detail so that over-expenditures can be recognized and corrective action taken.

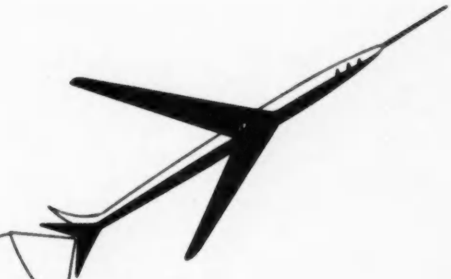
Responsibility for Cost Control

In at least one instance, a department rating program was used as a means of motivating supervision and the workers to reduce cost. Shop suggestion awards for better ways of doing the job were also cited as an aid in cost reduction. The use of wage incentives on a piece-work basis was ruled out as too cumbersome a system to establish and maintain in the airframe industry under the present continuous development of new models and changing manufacturing techniques. Use of piece-work incentives, where applicable in the plants of component parts suppliers, however, appeared to be a feasible plan for decreasing costs.

Line supervision was held to be the fundamental group responsible for actually taking steps to reduce costs, whereas staff groups were regarded as service agencies to assist line supervision wherever possible in doing the job. The belief was offered that two men in line supervision are especially important—the man in charge of a model or a major section of the plant, such as the fabrication shops, must "spark plug" cost control activity and the assistant foreman, or lowest level of supervision, must accomplish the expected result by working with leadmen and workers.

It appeared evident during the discussion that each company has developed good workable approaches to some of the problems of cost control. At the same time, it was also felt that the field is still wide open for devising new and better ways to control manufacturing costs.

(The report on which this article is based is available in full in multilithographed form together with reports of the 10 other panel sessions of the 1952 SAE Aircraft Production Forum. This publication, SP-300, is available from the SAE Special Publications Department. Price: $2.00 to members; $4.00 to nonmembers.)



5-Star Aeronautic Meeting Draws Record Crowds

THE FIVE STARS on the program of the SAE Spring National Aeronautic Meeting shone so brightly that they drew more members and guests to this annual event than ever before. Attendance zoomed to just under 2000.

★The 10 panels at New York's first SAE Aeronautic Production Forum held Monday, April 20 at the Hotels McAlpin and Governor Clinton brought out a total of 775 participants—all of whom went away with new ideas on how to insure quantity as well as quality in American aircraft. (A story on the Aeronautic Production Forum appears on page 81.)

★Twenty-six exhibitors displayed their products Tuesday through Thursday, April 21-23, just outside the room in the Hotel Statler where the technical sessions were held. (See list and pictures on page 85.)

★Some 800 at the dinner on Thursday evening, April 23 heard Mundy I. Peale, president of Republic Aviation Corp. speak on "U. S. Airpower Today and Tomorrow—An Appraisal of the Build-Up," and witnessed presentation of the Wright Brothers Award to W. J. Kunz, Jr. The dinner also celebrated the 50th Anniversary of Powered Flight.

★Over 100 SAE members and guests toured the Arnold Engineering Development Center at Tullahoma, Tennessee on Friday, April 24, exploring its Gas Dynamics Facility, Engine Test Facility, and Propulsion Wind Tunnel. (SAE Journal will carry in a future issue a feature based on the paper presented at the Meeting by Gaylord W. Newton of ARO, Inc., operators of the Engine Test Facility.)

★Ten technical sessions on Tuesday, Wednesday, and Thursday, April 21-23, attracted capacity crowds to the Hotel Statler's Skytop and Penntop. Tuesday's sessions on turbojets, rockets, and guided missiles were restricted to SAE members cleared specially for the sessions by the Air Force. Wednesday and Thursday sessions, including three on hydraulic and pneumatic systems, were open to all SAE members and guests.

The technical sessions left the impression that the British-built Comet is not setting the pattern for future U.S.-operated jet transport. Economics will dictate larger, faster American airplanes having pod-mounted engines. First large American-built jet transports will cost between \$4 million and \$5 million when they appear several years hence. Meantime, we have a lot of work to do on hydraulic systems for fast, high-flying planes—both commercial and military.

"The Comet is a fine airplane . . . it will do everything but make money." That seemed to be the consensus among the audience after presentation of a paper on Comet experience. American operators feel that they must have more favorable specific fuel consumptions—even if that means

waiting several years until better engines are developed.

American operators indicated also that they want more capacity, more speed, and more range. Spokesmen talked of jet transports having twice the carrying capacity of the DC-6 or Constellation and at least 50 mph more than the Comet's 500 mph.

American airplane builders are in sympathy with the desire for speed and will outdo each other in trying to provide it. As one manufacturer put it, "The company that builds the fastest jet transport will be the company that builds them." He and his colleagues talked of cruising speeds of at least 525-600 mph.

Wings thin enough to achieve these speeds will be too thin to accommodate engines within, they agreed. Best location for engines is in pods suspended from wings, it was felt. Besides cleaner aerodynamic configuration, designers extolled pod installations for lower bending moments, decreased fire hazard, and increased volume for fuel storage away from passenger compartment.

Arguments for pod-mounted engines were, in fact, so numerous that some wondered why the British have been using buried-in-wing installations. The answer given was that buried engines give extremely good control, even under one-engine-out conditions. Besides, whether or not engines are buried, wings are too thin to hold all the fuel and outside tanks are necessary, British designers believe.

While engineers at the meeting were not generally too enthusiastic about British jet transports, they did congratulate their British competitors heartily on their initiative in building jets and putting them into commercial service years before anyone else. British achievements were looked upon as a real challenge to the American aviation industries.

Many at the sessions conceded also that the British approach may be the best for them, even though their planes appear uneconomic for our airlines. At the end of World War II, operators in both countries needed new airplanes. The British, unlike us, had no large advanced piston engines to put in new transports. Designing around whatever turbine-type engines were available was practically their only hope.

Hydraulic Systems

Jets are forcing hydraulic-system engineers to search frantically for more heat-resistant hydraulic fluids, seals, pumps, packing, filters, and other components, the hydraulics sessions emphasized.

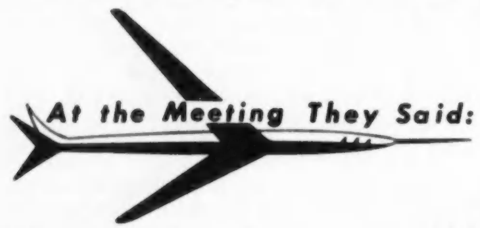
The heat comes from three sources: (1) skin friction generated by supersonic flight, (2) engine heat picked up by hydraulic lines snuggling close to the powerplant, and (3) latent heat in the hydraulic system.

Engineers from airframe companies asked for hydraulic systems that will hold up in temperature ranges roughly from - 65 F to 400 F. But no one wanted to be too specific. If airframe men specify exact temperatures, it will be easy for our enemies to figure out the Mach number of our super-secret planes under development. And if they indicate the desired duration of resistance to extreme temperatures, it will be a cinch to figure the range of our advanced planes.

One thing seemed certain. The search is turning into a heyday for chemists because new rubbers, elastomers, fluids, and plastics are going to have to be used.

Otherwise, take a hydraulic system up to 400 F and weird things happen to materials that are practically immune to deterioration at 200 F. For example, synthetic rubber o-rings take on a permanent set and deteriorate. Leather back-up rings char and disintegrate. Fluids deposit varnish-like coatings on metallic surfaces so that working parts freeze up. Pumps wear quickly, and some pump parts break down very early. Filters come apart because fibers separate from the laminate and the glue gives way.

Highlights from papers presented at the open sessions on jet transports, hydraulic systems, and other topics appear on following pages. SAE Journal will carry more extensive treatments in future issues.



Comet Experience

Clifford H. Jackson of British Overseas Airways Corp. in ***A Review of Comet Experience:***

● Using the Comet, we have established an economic operation at about twice our previous cruising speeds. We have confirmed certain favorable trends which should lead to lower costs and fares in the future. And we have learnt a great deal that will influence future aircraft and equipment designs.

● Although our maximum cruising and descent Mach number is about 0.74, we have not been worried with compressibility effects or control problems. In fact we could now contemplate with equanimity cruising with a future generation of aircraft to Mach 0.8 and retaining no more than say a 10% margin below the defined limit speeds.

● Since we see no prospect of substantially improved landing aids becoming internationally available for a good many years, we believe that attempts to raise cruising speeds beyond Mach 0.8 will be limited by the approach and landing requirements.

● Records of jet-turbine failures in the United Kingdom, including of course military aviation, show a remarkable decrease in the failure rate in the critical conditions of flight at take-off and climb. The trend has been confirmed in our own experience. Reliability of the turbine is such that almost no powerplant checks are required at transits.

● It is our intention to avoid the wide-cut gasolines and adhere to kerosene or other high-density, high flash-point fuels.

● We have not been caught on commercial operations by jet streams or clear air turbulence. But during our

survey flights to Tokyo, we have encountered jet streams which were not forecast.

- Forecast terminal weather data and actuals are proving more important than the en route data. Lack of meteorological data is reducing payloads directly and by leading to our requiring structural cover for a higher percentage landing weight than we had originally thought necessary. The percentage is, however, still lower than for our reciprocating-engined aircraft.
- Airport noise and jet damage to runways have not been problems. We have had no serious impeller or blade stone damage, and the few cases of nicking have caused no concern.

In the discussion period, it was said that:

BOAC has considered in-flight refuelling for the Comet but concluded it would be uneconomic.

Airplane Costs

J. W. Barton of Boeing Airplane Co. in ***Factors Influencing Airplane Costs:***

- If we assume that Jet No. 1 is going to have a gross weight of about 186,000 lb at a block speed of 460 mph, our prediction method indicates a total price of $4,560,000. We certainly cannot represent this number as being very precise. It should, however, be at least "in the ball park."
- We are undertaking at the preliminary design level to find the causes for increased cost and to determine basic principles which will result in lower costs. Operations research forms a large part of this program. We are consciously endeavoring to find what basic program will best fit the missions of both our military and commercial customers.
- On Project "X," our jet transport, we are following SAE recommendations wherever possible. We hope we can use this lever to achieve more standardization.
- Future commercial transport prices can be minimized by airline-manufacturer cooperation to minimize changes from basic specifications and differences between airline configurations.

In the discussion period, it was said that:

Let's not build up excuses. Let's not use the high cost of the Comet as an alibi. Sure, it would cost more to build the Comet here because of our higher labor costs. But we didn't get where we are now by competing on labor costs. Let's take labor costs as a challenge and make up for them by concentrating on the factors where we have the advantage. Some outfits will

Mundy I. Peale (left), who was principal speaker at the dinner, chats for a moment before the dinner with Toastmaster Admiral DeWitt C. Ramsey. Peale is president of Republic Aviation Corp. and chairman of the board of governors of the Aircraft Industries Association of America, Inc. Ramsey is president of AIA

Said Ramsey:

"In the period of my association and service with the AIA, I have become increasingly conscious of the splendid contributions the SAE has made and continues to make to the health and efficiency of our aircraft manufacturing industry. These are reflective of the spirit in which our joint undertakings have been conducted. They reflect a mutual confidence and a mutual trust—the essential ingredients of success. May this happy AIA-SAE relationship strengthen and continue through the years!"

Said Peale, in part:

"The very highest praise is due to thousands of your members from all types of industry who have unselfishly pooled their brains and brawn to effect spectacular savings in the construction of aircraft and aircraft components."

"I think it is becoming apparent to those of us deeply concerned with the security of the United States that we cannot go on shoving money into vending machines on the spur of the moment and have real air power come out. Building and maintaining air power requires a sane and sober program—a steady program—not a program of panic.

"The way to cut costs is not through small economies alone, important though their total may be. It is in the area of long-range planning that we can hope to make substantial savings in building up an adequate Air Force—the kind of substantial savings large enough to be felt by individual taxpayers."

Around the Meeting . . .

Aeronautic Production Forum panels at the Hotel McAlpin got under way to the howling of sirens. A guest of the hotel had plunged from a twelfth-floor window to the sidewalk, drawing a fleet of howling police vehicles, an ambulance, several photographers, and finally an undertaker's car.

Herman Hanink

The Aeronautic Production Forum got the glamour treatment on **Dave Garroway's** TV program "Today." **Herman Hanink**, a member of the Production Forum Executive Committee, proved himself quite a television personality as he and Garroway talked about and demonstrated the wonders of titanium, subject of one of the Forum panels. Hanink also played up the feminine angle on titanium by showing more than $3700 worth of titanium oxide jewelry.

SAE Committee A-6, Aircraft Hydraulic and Pneumatic Equipment cooperated with the Aircraft and Air Transport Activities in presenting the all-day, 10-paper program on hydraulic and pneumatic system problems on Wednesday, April 22. Tuesday, Thursday, and Friday, Committee A-6 devoted to its regular standardization work.

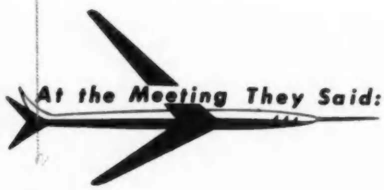
"Present-day ants are too small to strain out of our soup, so we might as well put them on our diet list," noted Convair's **Howard Field** in speaking about the small particles that get through filters in aircraft hydraulic systems.

Preprints of the 19 papers presented before open sessions are available from the SAE Publications Department, 29 West 39th Street, New York 18, N. Y. Order by author and title. Price is 25¢ each paper to members and 50¢ each paper to nonmembers.

Reports on all 10 Aeronautic Production Forum panels will be available in one package from SAE Special Publications Department, 29 West 39th Street, New York 18, N. Y. Order it as SP-302. Price is $2 to SAE members and $4 to nonmembers.

Frank Buchner and Hugh Harvey

Hugh Harvey of Shell Oil served as representative of the SAE Public Relations Committee for the week of the Meeting. He handled contacts with the trade press, newspapers, and radio and television commentators. Harvey was photographed at a press conference he had assisted **Frank Buchner** (in the background) of Curtiss-Wright in arranging. Present at the conference were Aeronautic Production Forum Sponsor **Roy T. Hurley**, president of Curtiss-Wright Corp., and several members of the Forum executive committee.



go ahead with turbine transports. Let us be among them.

The challenge of labor costs has already been accepted. Projected American jet transports are estimated to cost $12 per lb thrust instead of the $8 in England. That is, American jet planes will cost half again as much per pound thrust. But the American/British wage ratio is much higher. Average wage for aircraft workers here is $1.87 per hour. In England, it's 55¢.

The manufacturers have no right to pass on a price penalty for speed derived from the taxpayers' money.

Right! But the taxpayer pays for research. Development the airlines must pay for.

The manufacturers are sissies about changes. They shouldn't permit airline customers to make pointless changes. The only changes an airline should make are those involving items they find won't work—and these are always so few that they have no major effect on cost.

The manufacturers who have made the largest number of aircraft have paid the largest dividends.

That's true because they've been making military aircraft. No manufacturer—with one possible exception—has made a profit on commercial aircraft since the war. Boeing's profit was good this year—but the company didn't make any commercial aircraft. Changes constituted one third of Boeing's losses on the Stratocruiser.

Pod-Mounted Engines

George S. Schairer of Boeing Airplane Co. in *Why Pod-Mounted Engines Make Sense:*

- A pod-mounted engine installation will result in the best lift-drag ratio performance. But only by comparing completed actual airplanes can a fair comparison of overall performance be made. All comparisons available to the author have shown negligible differences in performance capabilities for different types of installations. The final choice between installations must be on factors other than performance.
- Pod engine installations have many very beneficial characteristics from a safety standpoint. The most obvious benefit lies in the greatly improved safety in case of a powerplant fire in flight. A small but important

advantage is the ability to isolate fuel, oil, or vapors emitted from the engine.

- Pod engine installations can be expected to provide cheaper airplanes. The structure of a pod airplane is quite simple and easy to build. And the ready accessibility to the engines make them easy to maintain.

In the discussion period, it was said that:

Stubbing a pod during landing usually does knock off the engine. Designers don't know yet whether it's better to strengthen the pod strut to prevent loss of the engine, or to make it easier for the engine to break off.

Control with one engine out has been no problem so far with pod planes.

Airport debris may not be as much of a problem to jet engines as expected. In a recent test, a jet wouldn't pick up a candy wrapper until it was placed on a tray only 18 in. from the inlet. Stones and ice will, of course, cause trouble.

The B-52 with eight big jets is quieter than the B-47 with six smaller engines. The B-47 is noisier with water injection than without. We have a lot to learn about noise.

Transport Turbojets

B. T. Salmon of Consolidated Vultee Aircraft Corp. in *High Speed Transport Turbojet Installation Considerations:*

- The buried turbojet powerplant cannot be justified.
- A turbojet transport designed to cruise below 525 mph is not likely to be worth the effort of designing and building it, even if a potential customer could be found. A 525-mph airplane will have an average wing thickness of 11%. A 600-mph airplane should have not over 6% average wing thickness. Even though wing chord increases as thickness is reduced because of decreasing aspect ratio, the net effect is to reduce the available wing depth to less than the dimensions required to accommodate a buried powerplant installation.
- If the 120-deg jet noise cone intersects the fuselage shell ahead of the cabin aft bulkhead, no reasonable amount of soundproofing treatment can lower the cabin noise to a tolerable level. Thus, passenger comfort is the controlling factor in fixing the practical location of the jet exit nozzle.
- The specific fuel consumptions obtainable from the twin-spool engine are materially better than from earlier types. Perhaps of equal importance is the ability of twin-spool machines, with the aid of water injection, to maintain relative freedom from take-off loss at elevated outside air temperatures. Single-spool engines tend

. . . Around the Meeting

Dixon Speas (center) and his launching crew fired up the models which saluted the Fiftieth Anniversary of Powered Flight by making a pass over the guests assembled at the dinner. First a replica of the 1903 Wright Brothers' pusher plane flew across the ballroom. Then three jet fighters zoomed after it. Sound effects added a realistic touch.

Serving as **chairmen of technical sessions** at the Meeting were:

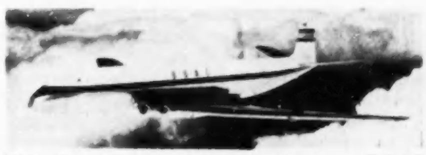
A. T. Colwell, Thompson Products, Inc.
C. C. Furnas, Cornell Aeronautical Laboratories
A. R. Parilla, M. W. Kellogg Co.
F. O. Hosterman, Weston Hydraulics, Ltd.
Capt. W. T. Hines, U.S. Naval Air Turbine Test Station
Harry Cornish, Douglas Aircraft Co., Inc.
O. E. Kirchner, American Airlines, Inc.
A. H. Hobelmann, Walter Kidde & Co., Inc.
W. E. Littlewood, American Airlines, Inc.
H. E. Gray, Pan American World Airways, Inc.

For **reports on the discussion** at technical sessions, SAE is grateful to:

F. H. Pollard, Republic Aviation Corp.
E. G. Whitney, Fairchild Engine & Airplane Corp.
R. E. Middleton, Lockheed Aircraft Corp.
O. E. Kirchner, American Airlines, Inc.
H. F. Peppel, Walter Kidde & Co., Inc.
R. D. Speas, Aviation Consultant

Admiral Ramsey, in his introduction of SAE President **Robert Cass** at the dinner, noted that Cass served as a chief petty officer in the Royal Navy during World War I and remarked that from the highest brass to the ship's cook, all hands admit that the CPO is the backbone of all naval organizations.

"Very glad to hear an admiral acknowledge it," shot back ex-CPO Cass.



C. H. Jackson's audience shared some of the delights of a Comet flight from London to Rome, Khartoum, and Johannesburg by watching a movie the British Broadcasting Corp. made on a BOAC preview flight to show on television.

New York to Tullahoma Non-Stop

Col. Frank N. Moyers greets SAE Vice-President E. G. Haven as SAE members and guests step off the chartered plane that flew them to Tennessee to tour the Arnold Engineering Development Center at Tullahoma. The group took off from LaGuardia Field at 7:00 a.m. and arrived back there right on schedule at 10:10 p.m.

The 38 who came by SAE-chartered DC-6 met 65 others at AEDC's cafeteria, where Colonel Moyers, who is vice-commander of AEDC, briefed them on the tour. Then the group divided into four parties for separate guided tours of the Gas Dynamics Facility, the Engine Test Facility, Propulsion Wind Tunnel, and the cooling-water reservoir.

Purpose of the visit was to acquaint prospective users of AEDC's testing services with the equipment available.

At the Meeting They Said:

to show large thrust losses under such conditions.

In the discussion period, it was said that:

Big jet transports with only enough power to cruise at 500 mph may be take-off limited. Airline operators fear that jet engines available today just aren't powerful enough to offer really high speeds, profitable capacity, and still keep out of take-off trouble.

Water injection cuts down the degree of hot-day power deterioration. An engine that delivers 9500 lb thrust at 60 F or 7200 lb at 100 F without water injection delivers 11,200 lb at 60 F and 10,450 lb at 100 F with water injection.

Half-inch-thick armor plate wrapped around a turbine so that it extends ½ in. fore and aft of the turbine will insure that broken blades go out the tailpipe instead of cutting a tangential swath, it has been found with the Allison T-40.

Jets for Airlines

W. W. Davies and H. N. Taylor of United Air Lines in *Jet Engines from the Operators' Viewpoint:*

- Jet engines have delicate appetites. Nuts, bolts, wrenches, and runway debris severely tax the digestive ability of the jet engine. It is obviously better to provide protection against such unpalatable morsels by means of location than by complicated closure devices.
- Design should be such that for the few times that a fire may occur, ample protection is provided for the remaining portions of the airplane. This implies locating the engine away from primary aircraft structure or providing maximum firewall protection.
- Maximum consideration must be given to the effect of engine location on wheels-up landings. The jet engine retains enough heat to support combustion from fuel spilled from torn tanks.
- If some parts of this whirling dervish should happen to come loose, what happens? The proximity of jet engines would seem to make such failures contagious. Either jet engines must be located so that failure of one cannot cause failure of another—or they must be protected against mangling each other.
- Besides safety, we strive hardest for passenger comfort and service reliability. In whatever configuration it may assume, the jet transport must be so designed as to enable us to realize all three objectives when we place it in service.

In the discussion period, it was said that:

Turbine blade losses don't do so much damage as compressor blade losses. As far as Republic installation engineers know, there hasn't been a single instance of serious difficulty due to turbine disc failure on any of the 4000 operating Thunderjets. Turbine buckets usually burn in from the tips. (Exception to this was the case of eight jets lost in Indiana in a freak storm two years ago. Icing caused the blades to burn at the center, and the severed pieces went out like shrapnel.) Compressor blade failures are dangerous because the flying blades are likely to cut hydraulic and fuel lines and result in fire.

At the Meeting They Said:

Hot Hydraulics

Frank C. Mittell of North American Aviation, Inc. in *High-Temperature Problems Associated with Aircraft Hydraulic Systems:*

• Heat transferred from jet engine and tailpipe plus aerodynamic heating on a Mach 1.5 airplane raise hydraulic system components to temperatures far in excess of the presently allowed 160 F.

• However, present systems function satisfactorily at 200 F except for MIL-H-5511 flexible hose, preliminary tests suggest. With better hose and a suitable pump, most hydraulic systems are all right at 250 F if leather backup rings are replaced with teflon and allowance is made for possible o-ring failure after extended high-temperature running. These changes plus replacement of the standard paper filter element with a sintered metal filter would make the system adequate for 300 F.

• Much more drastic changes are indicated in the 300-400 F region. A great deal more research and development will be required before the o-ring, for example, can be used beyond 300 F.

In the discussion period, it was said that:

There was a pattern of sameness in pump failures in the 300 F test. The valve face plate showed increased roughness. In one case the pump broke down because of a knuckle joint failure.

The MIL-H-5511 hose broke down above 160 F largely because the hose inner liner started to let go. Solenoids failed because of insulation breakdowns.

Hydraulics: A Challenge

George R. Keller of North American Aviation, Inc. in *Adventures in Extreme Temperature Hydraulics:*

• Testing has shown that, for some sets of operating conditions at least, hydraulic operation is feasible over a much wider range of temperatures than was heretofore deemed possible.

• However, because the properties of fluids change tremendously with temperature, it may well be that the range of temperatures over which any one fluid can be operated has been stretched nearly as far as it can go. If operation at higher temperatures is to be considered, shifting of the range upward may have to replace sheer extension of the range. This would mean that the present requirement of operation at −65 F might suffer compromise.

• Perhaps an entirely new approach to the sealing problem is required. The reed and chevron seals, difficult as they are to use, may well be pointing the way to a fresh solution to the sealing problem.

• Until more knowledge of the internal mechanics of hydraulic pumps is gathered, the development of a pump which is efficient at high temperatures and which takes the fullest advantage of the limited lubricity of the available fluids at high temperatures may well be the hardest problem of all.

In the discussion period, it was said that:

Fluorocarbon fluids were eliminated from consideration as high-temperature hydraulic fluids because of their poor viscosity index characteristics.

Differences in performance between the various fluids tested lay not with the base fluids, but rather with the additive formulations. The fluids were basically silicate esters. One additive that made a difference was the viscosity index improver. It tends to cut down high-temperature stability.

Flexible metal hose might do for hydraulic systems. North American is looking into it. But here's the trouble with the stuff: Suppliers will furnish flexible metal hose up to ¼ in. in diameter that will meet burst pressure specs. Larger diameter hose just won't perform satisfactorily in impulse testing.

Synthetic Packings

E. L. Carlotta and E. M. Hobein of The Parker Appliance Co., in *Limitations of Synthetic Rubber Packings for High Temperature Application:*

• When rubber is exposed to temperatures high enough to cause a relatively rapid breakdown of the molecular structure, other processes which favor degradation are also accelerated. Thermoplastic properties show up and deterioration by oxidation occurs.

• At the same time, though, there is always available within the rubber a potential for cross-linkage which will tend to repair some damage caused by degradation. If the design and environment of an application can be controlled to take advantage of this potential recapture of characteristics, it can in effect contribute to the life of a rubber seal or gasket. This means not only controlling temperature but also controlling other factors in the application.

• It would seem reasonably safe to predict that in spite of extensive work to develop new and better polymers of the elastomeric type, the complete solution to hydraulic and pneumatic rubber problems with high temperatures is many years off. Probably the major portion of work will fall to the rubber compounder working with the materials already available but using new compounding ingredients other than the base polymer.

• A new plasticizer would contribute to better high-temperature rubber. The di-ester type oils are presently the only plasticizers which can meet −65 F requirements in many cases.

In the discussion period, it was said that:

What happens when a rubber seal breaks down varies from compound to compound. But basically, the seal reaches a point where the molecular structure breaks down, flexibility vanishes, and generally the hardness value goes straight up and the material no longer behaves as a rubber.

Hydraulic Fluids

J. C. Mosteller and Lt. J. A. King of Wright Air Development Center in *The Development of High Temperature Hydraulic Fluids:*

• The United States Air Force is seeking a fluid for high-temperature hydraulic systems that will be a satisfactory lubricant from −65 F to 400 or 600 F, meet all the other requirements of a good hydraulic fluid, and be producible from readily available materials.

• One may predict, on the basis of recent research studies, that silicates can be produced that have suitably high flash points and stability. Hence, silicates will be of increasing importance for high-temperature fluids of the future.

• Continued efforts to improve the lubricity and thermal stability of the polysiloxanes will undoubtedly produce materials useful in the high-temperature program.

• The more unique synthetics such as polynuclear aromatics, organometalloidal and or ganometallic compounds now in the test tubes of Air Force scientists will also play a part

At the Meeting They Said:

in future high-temperature hydraulic fluid development.

In the discussion period, it was said that:

Wright Field has written a tentative specification for a silicate base fluid called Fluid "D." This material is considered to most nearly meet requirements for a high-temperature fluid. The specification, before it is published, will be circulated to the industry for comment.

Lt. King noted that nonflammability was considered as a must in the first three years of the high-temperature fluid program. But right now it looks next to impossible to get both nonflammability and other needed properties. The phosphates may come close to satisfying both requirements if more suitable metal deactivators could be developed.

Hydraulic Reliability

Leo Morse Chattler of the Bureau of Aeronautics, Department of the Navy in *Design for Increased Reliability of Aircraft Hydraulic Systems:*

- I am not one of those people who believe that we can design a modern high-speed, high-altitude, high-performance, inhabited aircraft to be an accurate gun or bombing platform without some gadgets and some complexity—although I do believe that a great effort should be made to keep both gadgets and complexity to an absolute minimum.
- I believe the aircraft designer can overcome a great many of the above difficulties by:

1. Designing to a range of requirements rather than specific estimated requirements.
2. Obtaining a review of the system by the most competent personnel in the plant in addition to the procuring agency at a very early stage in the design.
3. Reviewing the system from a "why won't it work" viewpoint—in other words, performing a failure analysis on the system.
4. Eliminating marginal situations—that is, if the system appears to be marginal in certain aspects, redesigning without waiting to find out whether it will work.
5. Redesigning instead of accepting a marginal situation when a new requirement arises which requires inclusion of an additional subsystem and jeopjardizes the basic system.
6. Influencing management to give installation preference for important systems.

Tomorrow's Hydraulics

Howard Field, Jr. of Consolidated Vultee Aircraft Corp. in *Designing Hydraulic Systems to Increase Dependability of Tomorrow's Airplanes:*

- It is up to the hydraulic engineer and each other engineer to see that in his zeal to improve his own playthings, he improves the airplane as a whole.
- Many Corliss engines have run for years without ever stopping. Obviously, putting a Corliss engine together with its boilers in an airplane will greatly improve powerplant reliability. It also makes the airplane perfectly safe from flight hazards. Ridiculous? Of course.
- Temperature conditions are certain to be more severe in the future. Temperatures around 400 F can be expected in a few years. Also extreme altitude may subject comparatively slow airplanes to conditions where little used hydraulic units will get very cold. We believe that temperatures at least as low as - 100 F must be provided for, except in puddle jumpers.
- Present trends seem to point to closer and closer tolerances and fits in manufacture. We feel that this trend has long ago passed the point of diminishing returns and must be reversed.
- Higher unit pressures should increase dependability. Equipment to work at say 7500 psi could be developed if needed. Such high-pressure components would be smaller and thicker-walled—which means more robust construction at less total weight. Line losses will be proportionately smaller and viscosity less important.

Designing Hydraulics

J. W. Kelly of Adel Division of General Metals Corp. in *Design and Development of Aircraft Hydraulic Components for Increased Reliability:*

- We have become well standardized in our method of endurance testing—perhaps too well standardized. There should be more attention given to approaching the actual installation requirements. Of what value is a 20,000-cycle endurance test on a unit which receives 600 cycles per flight? On the other hand, why require a unit subject to only one cycle per flight to be operated 20,000 times?
- We should be very careful also in

Entering Confidential Session . . .

SAE members on their way to the three confidential sessions held Tuesday, April 21 had to produce cards issued by SAE to show that they had been cleared specifically for these sessions by the Air Force.

The confidential sessions included papers on turbojets by J. D. Clark of the Navy Bureau of Aeronautics and R. W. Kinney of Wright Air Development Center; papers on guided missiles by J. M. West of Bell Telephone Laboratories, R. C. Blaylock of Chance Vought, and Allen Puckett of Hughes Aircraft; and papers on rockets by C. C. Ross and J. J. Peterson of Aerojet, J. H. Wyld of Reaction Motors, and Alfred Voedisch, Jr. of the Air Technical Intelligence Center

conducting low temperature tests on units to duplicate as closely as possible the actual conditions. For example, one of our solenoid selector valves that is a spring-centered slide valve was tested in accordance with the military requirement that an adequate amount of oil be in the cold box at −65 F prior to starting the test. One of our customers tested this valve in a slightly different fashion, having the valve installed in the cold box, a short length of line between the valve and the wall of the cold box, and the operating pump and reservoir outside at room temperature. This set-up is closer to actual operating conditions.

• The test consisted of turning on the pump, letting it operate a few minutes under full bypass condition, which causes the oil to heat up, and then operating the valve. As soon as the small amount of cold oil had gone through the valve, a condition was reached wherein hot oil was introduced to one half of the valve as cold oil was leaving the other half. This produced binding not apparent in all the previous −65 F testing.

In the discussion period, it was said that:

Catalogs would get too bulky if manufacturers listed all the tests various units had been given.

The suggestion that unit tests more closely approach actual installation conditions is not meant to upset the test standardization program underway.

The best way to ensure uniform temperature in a −65 F ambient test is to leave the unit in the cold room for over 24 hr.

Hurley Talks to Press

At a press conference, Roy T. Hurley, sponsor of the Aeronautic Production Forum (standing), told more than 30 reporters and trade paper editors that processing information holds the key to reducing costs in aeronautic production. He said: "This Aeronautic Production Forum is a prime example of one way in which industry at large can meet to discuss its problems and share its achievements. In this fashion, all of us get the accrued benefits of the enormous experience that is represented here by hundreds of top-notch men in such fields as manufacturing, procurement, quality control, and metallurgy."

Designing Pneumatics

Milton Slawsky of the National Bureau of Standards, Albertus E. Schmidlin of Walter Kidde and Co., Inc., and Morton Lutzky of the National Bureau of Standards in *A Method for Predicting Pressure Drops in Pneumatic Components and Systems:*

• The characteristic curve of a valve is a plot of Q/P_u versus P_d/P_u, where Q is flow, P_u is absolute pressure upstream of the component, and P_d is absolute pressure downstream of the component. This curve has the advantage that it does not require the plotting of a curve for each upstream pressure.

• The flow factor, or value of Q/P_u at $P_d/P_u = 1/2$, determines with fair accuracy the complete characteristic curve, and may therefore be utilized as a single parameter to describe a fixed-orifice component. For certain simple cases the flow factor is 16.5 times the area of the tubing in square inches.

• Various analytic formulas have been developed to represent characteristic curves. With these formulas it is possible to derive flow coefficients for a system of components in series. Thus, a pneumatic system may often be described by a single flow factor, if tubing is neglected.

• When the tubing is not neglected, but treated as a component, then the flow factor for the tubing is 23.5 times the area of the tubing times the square root of the dividend of the diameter of the tubing and the product of the friction factor and the length of tubing. (Dimensions here are in inches and square inches.)

Military Pneumatics

Robert R. Bayuk of Wright Air Development Center in *Pneumatic Actuating Systems in the U.S. Air Force:*

• Big difference between pneumatic and hydraulic systems is that in a pneumatic system a low-powered compressor running continuously can store energy for later intermittent use at unlimited horsepower rates—while the hydraulic system's pump must be sized for the largest horsepower requirement of the system.

• The transmission of energy by air is inherently less efficient than by hydraulic fluid, since the heat of compression is lost to the system. And it will be found that in most cases the air compressor weighs more than the hydraulic pump which it replaces. However, the total pneumatic system weighs less than the comparable hydraulic system. The prime weight saving in the pneumatic system is due to the small lines used, the complete lack of return lines, and the small weight of air in comparison to the hydraulic fluid weight.

• Pneumatic systems look good for low-temperature operation. Leakage and freezing of some components may be problems. But the freezing problem can be completely eliminated by reducing the vapor pressure of the water in the air to a point which will prevent the formation of ice. The compresison of air will automatically remove 99.0% of the water at 1500 psi and 99.5% at 3000 psi. A dessicant such as silica gel will remove remaining moisture satisfactorily.

• We should look at each airplane with the idea of securing the lightest system to do a job. If pneumatic systems are lighter, we should use them. If a combination of hydraulics and pneumatics proves optimum, we should utilize both.

In the discussion period, it was said that:

Some 3000-psi compressors are now in service in Korea.

It takes an 8-stage compressor to deliver 3000 psi line pressure.

At the Meeting They Said:

Testing at Tullahoma

G. W. Newton of ARO, Inc. in *Simulated Flight for Engines at AEDC:*

• The Arnold Engineering Development Center (AEDC) at Tullahoma, Tennessee provides a complete engine testing facility. It is designed for full flight operation of turbine and ram type engines in test chambers. Proper conditions are set up for performance and endurance testing under the atmospheric temperature ranges and altitudes encountered in flight.

• AEDC is one of eight experimental centers under the Air Research and Development Command. AEDC is managed and operated by a private corporation under contract to the Air Force. Besides serving the Air Force and other military services, AEDC will be available to industrial organizations and educational institutions engaged in propulsion and aeronautical research and development.

• Approximately $170,000,000 has already been appropriated by Congress for construction at the site in Tullahoma. The AEDC is located on a 43,000-acre tract of government land. Its off-site reservoir is over 12 miles long and includes an ample quantity of cooling water for the test facilities.

The three test facilities are the Engine Test Facility, the Gas Dynamics Facility, and the Propulsion Wind Tunnel. Each facility has its own air supply, and the systems are interconnected so that very great flows are available to each facility.

• To avoid delays introduced by manual methods of recording and reducing data, an automatic data reduction system will be installed in each of the facilities. The equipment will provide for transfer of all measured temperatures, pressures, electrical outputs, and motions to digital form and then automatic computation and printing or plotting of the final corrected results. A tape record is kept of the raw data.

Final data will be available at the test cell within 30 sec for each test point. This will insure accurate setting up of test points. The automatic data reduction systems will be in operation early in 1954.

In the discussion period, it was said that:

Both the AEDC facilities and the Lewis Lab are part of a unitary wind tunnel plan outlined in Public Law 415 passed by the 81st Congress.

Policies on payments for testing haven't been laid down yet. The Air Force will probably conduct the initial tests on its own funds. The cost system contemplated charges direct costs (like those for fuel, water, and personnel) to the organization for which the tests are performed, and charges overhead to the Air Force.

Turbojet Research

W. A. Fleming and H. D. Wilsted of Lewis Flight Propulsion Laboratory, NACA in *Turbojet Research Techniques Utilized in Altitude Facilities:*

• An automatic pressure recording device has been developed at the Lewis Laboratory and will soon be put into use in the turbojet altitude facilities. This device will measure as many as 100 pressures in about 10 sec. Then it will record them on punched tape, punched cards, or an automatic typewriter.

• A similar device is being developed at the laboratory for rapid recording of temperature measurements. In fact, it is already in limited use. This device will reduce the time required to record temperature measurements from about 4 min to about 15 sec.

• Two methods of extending maximum altitude or Mach number limits of altitude facilities have been developed at the Lewis laboratory: (1) diffusing the exhaust jet to recover some of the jet kinetic energy in the form of static pressure; and (2) varying engine inlet conditions to simulate a range of flight conditions while operating with the exhaust nozzle choked. (With the nozzle choked and the flow velocity sonic, pressure variations cannot be transmitted back to the engine. The engine doesn't know that exhaust pressure hasn't been reduced way down to the correct altitude value.)

In the discussion period, it was said that:

Sealing at the inlet instead of around the exhaust gives easier access to the hot part of the engine, which is where the most work must be done while the engine is in the test cell. A bypass valve lets a small amount of air in to circulate around the engine to cool it.

Facilities like the Lewis Flight Propulsion Laboratory and the Engine Test Facility of the Arnold Engineering Development Center probably won't be used for testing rockets. Their exhaust products would corrode the exhaust ducting.

Fuel Economy

H. E. Alquist of Phillips Petroleum Co., E. A. Droegemueller of Pratt and Whitney Aircraft, and H. N. Taylor of United Air Lines, Inc. in *Aviation Fuel Economy and Quality—Brothers Under the Aircraft Skin:*

• Since the aircraft piston engine has nearly reached the ultimate in mechanical development, it is a logical time to start weaning the beast.

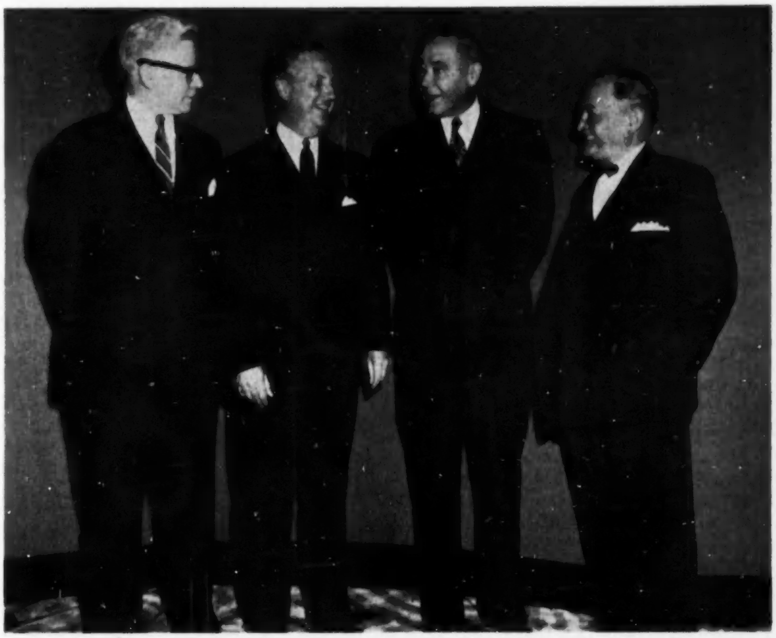
• Although manual lean operation is more critical of fuel quality than automatic operation, it seems that significant improvement can be made in cruising economy with the average 1951 production fuels. This is possible because (1) partly through engine design, the present cruise operating points are much further than necessary from the knock-limited powers available with some specification fuels, and (2) the average production aviation gasolines since the war have been considerably better than the specification requires.

• Some field experience and test data indicate that the gain in cruising economy available by more severe operating conditions can be attained without jeopardizing engine reliability and at the same time improve the smoothness of engine operation if the average 1951 fuel quality characteristics can be guaranteed and if the operators exert utmost diligence in equipment maintenance and crew training. For the longer-range aircraft, an improvement of 5 to 7% probably could be effected over best power-retarded spark cruise settings.

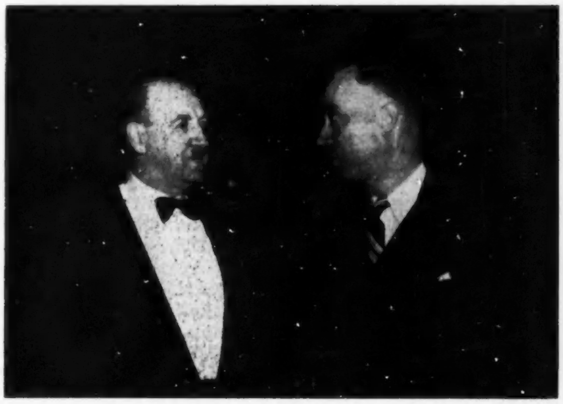
In the discussion period, it was said that:

On current fuels in the international scene there is less margin on volatility and antiknock value than is shown in the 1951 fuel survey. Unless there is positive assurance that the margins exist in better than 90% of the fuels being delivered to a given airline, full advantage cannot be taken of the optimum cruising regimes described. The only way to assure the margins is to rewrite the fuel specification. Desirable as this might be from an operator's standpoint, we are of the opinion that such a step would meet with

Around The Dinner



The four men who did the speech-making after the dinner pose together. They are (left to right): SAE President Robert Cass, Dinner Speaker Mundy I. Peale, Toastmaster Admiral DeWitt C. Ramsey, and SAE Metropolitan Section Chairman Leslie Peat



Otto Kirchner (left) confers with Thomas Neill. Kirchner is SAE vice-president for the Air Transport Activity and Neill is vice-president for the Aircraft Activity

Harold R. Harris (left), chairman of the Aircraft Engineering Display Committee, gives a report to Rudolph F. Gagg, general chairman of the Meeting

R. C. Loomis (left) presents to W. J. Kunz, Jr. the scroll awarded to Kunz along with the Wright Brothers Award medal. Kunz received the Award for his paper "A New Technique for Investigating Jet Engine Compressor Stall and Other Transient Characteristics," which he presented at the 1952 SAE National Aeronautic Meeting in New York a year ago. Loomis is chairman of the Wright Brothers Board of Award

At the Meeting They Said:

something less than enthusiastic response on the part of the majority of aviation fuel suppliers.

Many compromises have to be made when one is buying fuel, so one must accept some variation in it.

The real return from lean mixtures comes when one gets beyond the minimum brake specific and gets into the minimum thrust specific.

Instrument Lighting

J. H. Achilich of the Special Devices Center of the Office of Naval Research in *Aircraft Instrument Integral Lighting:*

● It is our firm belief that the major solution to the overall problem of cockpit panel lighting is integral lighting of the individual instrument.

● The Special Devices Center has developed an integral lighting system. It incorporates a light source at the center of the instrument window, which illumines translucent dials and pointers but not the rest of the instrument face.

● This method of integral lighting encompasses the main requirements for dark adapation—that is, low level illumination, a minimum of reflections, and a minimum of light spillage on the instrument panel.

In the discussion period, it was said that:

Cost in actual production would probably not bear any relation to the cost of modifying the instruments experimentally.

There are a number of ways of hermetically sealing these instruments.

A group of titanium parts and test specimens furnished by Watertown Arsenal and Rem-Cru Titanium gave participants at the Titanium Panel a chance to examine, feel, and better understand facts reported in discussion

Cockpit Standardization

M. G. Beard of American Airlines in *Cockpit Standardization—How Far, Now and in the Future?:*

● SAE Committee S-7 on Cockpit Standardization was formed in November 1949 to fulfill the obligation of industry to monitor itself with respect to uniformity of airline transport cockpits—or be regulated in this respect by the CAA and the CAB. Committee S-7 is composed of pilots of long experience, well up in administrative positions, and having wide experience in special fields of airline flying and operation, instrument flying, and development testing of new transport airplanes.

● The accomplishments of Committee S-7 to date include: ARP 264B—Instrument and Cockpit Lighting for Commercial Transport Aircraft; ARP 268—Location and Actuation of Cockpit Controls for Commercial Transport Type Aircraft; AIR 32—Cockpit Visibility for Commercial Transport Aircraft; and AS 278—Cockpit Instrument Panels for Commercial Transport Aircraft.

● All future new commercial and military transport models should be constructed with the cockpits conforming to the recommendations. However, any movement to standardize flight instrument panels and controls on existing transports would lead to great confusion and create unnecessary hazard during the transition period. It would also be very expensive, and therefore should not be done except where interchange agreements between airlines make it necessary.

● In time of national emergency, the instrument flight panel and certain power controls should be standardized on planes assigned to military airlift. These changes could be prepared for and parts stocked against the time of necessity.

In the discussion period, it was said that:

It is most important that the manufacturing companies endeavor to comply completely with the published SAE Aeronautical Standards or Recommended Practices and do not adopt the attitude that "our design philosophy does not agree with these criteria" or "our flight test group feels that this is unnecessary."

The first aircraft built to these specifications will, undoubtedly, uncover items with which it will be difficult to comply, making some revisions necessary. This is the main reason why, at this time, most of the specifications are in the form of SAE Aeronautical Recommended Practices rather than Aeronautical Standards. After a shakedown period, they will undoubtedly become Aeronautical Standards.

Production Trends Noted At Panels

PRODUCTION tricks, trends, and "truisms" were recurrent topics at the ten Production Forum panels as more than 800 manufacturing men traded:

- Tricky techniques for producing troublesome aircraft parts.
- News about today's trends in machine tools.
- Thoughts on production "truisms" —taking old ones down a peg . . . setting forth new ones.

One participant at the Precision Forming and Joining session, for example, revealed that forming can be done at high speeds. It's just a matter of going through the yield point slowly, he said. As for high-temperature brazing, it was suggested that stainless steel be micro-brazed so as to get good corrosion resistance.

As for machining high alloy materials, one trick is to heat-treat the piece first, according to a panel member at the Machining session. The so-called truism that soft materials machine better than hard ones doesn't always hold true. They can result in poorer surface finishes. Still another good rule to follow in machining alloy-rich materials is to use sulfur-base chlorinated cutting oils, someone else reported.

What's-the-best-way-to-make-them queries directed at the Jet Engine Buckets and Blades panel drew the answer—there is no "best" way. Various methods have their advantages and disadvantages. In many cases, the method employed depends on the end use for the buckets and blades and also on the production background of the company making them. If the latter is especially experienced in machining, then it would make the blades this way. If the company specializes in forging, then it will no doubt forge them.

The men who planned, developed, and administered the Aeronautic Production Forum are Sponsor Roy T. Hurley, chairman and president of Curtiss-Wright Corp. (left), and Dr. Michael Field, partner of Metcut Research Associates, who was general chairman of the Forum

Production FORUM

Other revealing information came out of the "no gripe" Titanium session where experts announced the stuff isn't proving as difficult to machine as it was once thought it would be.

Many production men itched for a chance to use the machine tools they heard described at Machine Tools and Tooling, Large Forgings and Castings, and Machining panels. Soon-to-ar-

rive milling machines that can run at 10,000 rpm and broachers that can operate up to 120 fpm are just what the doctor ordered. But there's still a crying need for other varieties of machine tools that will take heavier cuts at higher speeds, it was brought out.

The monster forging and extrusion presses the U. S. Air Force has in the works will relieve some of this pressure for hopped-up machine tools, some production men predicted. That's because these goliath machines will be able to squeeze out huge one-piece aircraft structural parts to finished or nearly finished dimensions.

But as everyone knows it takes more than just super-duper machine tools for production success. Panels on Inspection and Quality Control, Production Procurement, Experimental Engineering, and Manufacturing Management revealed specific examples of what other departments can—and can't—do.

Quality control charts make excellent fact-finding tools, but don't count on them to be preventive tools was one bit of advice passed out. What's more, while statistical quality control is extremely useful, it, too, is no panacea, according to another manufacturing expert. The same thing was said of electronic calculating machines as procurement tools. By the same token, prime contractors can go just so far in lending assistance to experimental subcontractors, someone said. Technical help will be willingly given, financial assistance won't.

Making use of psychological and aptitude tests can help employers boost their number of "right" selections—but not more than 10 to 12%, warned one management man. The audience at this Manufacturing Management panel also learned that personnel turnover and evaluation records are well worth keeping. In this way, men can be spotted and primed for key executive jobs. Thus, there's less chance for small companies to be caught holding the bag when executive positions are suddenly vacated by retirement or death.

These and other thoughts expressed at the ten Forum sessions will appear as feature articles in future issues of SAE Journal. These articles will be based on reports of individual panel secretaries.

In the meantime, all these reports have been multilithographed and combined as an SAE Special Publication—SP-302. This package is available right now to SAE members for $2 and to nonmembers for $4.

PRODUCTION PROCUREMENT

(Left to right) A. C. Hartman, Air Associates; D. C. Fehleisen, Fairchild Engine and Airplane; Panel Leader J. Ralph Walker, Fairchild Engine and Airplane; C. E. Reid, Republic Aviation; E. T. Sturgis, Jr., Glenn L. Martin

LARGE FORGINGS AND CASTINGS

(Left to right) G. D. Welty, ALCOA; W. A. Dean, ALCOA; Frank Herlihy, American Brake Shoe; W. C. Schulte, Curtiss-Wright; Secretary J. R. Douslin, Wyman-Gordon; Panel Leader G. W. Motherwell, Wyman-Gordon; Alexander Zeitlin, Loewy Construction Co.; Gerhard Ansel, Dow Chemical; and Paul P. Zeigler, Kaiser Aluminum and Chemical

PRECISION FORMING AND JOINING

(Left to right) J. S. Sohn, Wright Aeronautical; Secretary M. H. Joyce, Jr., Budd; Panel Leader Michael Watter, Budd; W. H. D'Ardenne, Heintz Mfg.; H. M. Webber, General Electric; and F. J. Gardiner, ITE Circuit Breaker

TITANIUM

(Left to right) W. S. Hazelton, Westinghouse Electric; Robert Stewart, Allegheny Ludlum Steel; Secretary Robert Jaffee, Battelle Memorial Institute; Panel Leader W. L. Finlay, Rem-Cru Titanium; Paul Maynard, North American Aviation; R. J. Bullock, Wyman-Gordon; and L. D. Jaffe, Watertown Arsenal Laboratory

MANUFACTURING MANAGEMENT

(Left to right) R. T. Nalle, Jr., Westinghouse Electric; P. F. Weber, Kollsman Instrument; Secretary D. F. Timberlake, General Electric; Panel Leader H. Ford Dickie, General Electric; F. Penn Holter, Curtiss-Wright; C. L. Farrand, Farrand Optical Co.; and Harry Lampe, Republic Aviation

JET ENGINE BUCKETS AND BLADES

(Left to right) J. V. Rickard, Curtiss-Wright; L. M. Raring, Utica Drop Forge and Tool Corp.; C. P. Brooks, Austenal Laboratories; Secretary C. C. Clark, Thompson Products; Panel Leader W. M. Williams, Thompson Products; E. H. Jones, Ex-Cell-O; R. L. Grunewald, General Electric; P. C. Ambrose, Pratt and Whitney Aircraft

Please turn page for more pictures

MACHINE TOOLS AND TOOLING

(Left to right) Henry Maehl, Fairchild Engine and Airplane; J. L. Geist, Westinghouse Electric; Secretary Adam Hetzer, Republic Aviation; Panel Leader A. Kastelowitz, Republic Aviation; J. E. Bateman, Ford; W. M. Engelbrecht, Chrysler; J. J. Jaeger, Niles-Bement-Pond Co.; and Richard Stegler, Republic Aviation

EXPERIMENTAL MANUFACTURING

(Left to right) E. N. Laurance, Glenn L. Martin; Karl Scheucher, Thompson Products; J. W. Chalupa, Westinghouse Electric; Panel Leader Allan Chilton, Wright Aeronautical; Secretary G. E. Nelson, G. E. Nelson Co.; Joseph Ballard, Pratt & Whitney Aircraft; and P. W. Schipper, Douglas Tool Co.

INSPECTION AND QUALITY CONTROL

(Left to right) Frank Shaw, Shaw Metal Products; F. W. Rohde, Westinghouse Electric; E. J. Zalanka, Republic Aviation; Secretary D. E. Taylor, Pratt & Whitney Aircraft; Panel Leader E. S. Marks, Pratt & Whitney Aircraft; C. W. Kennedy, Federal Products; and E. D. Bryant, Fairchild Engine and Airplane

MACHINING

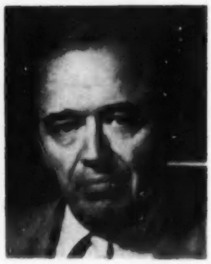
(Left to right) D. C. Aldrich, G. F. Pierce Co.; W. D. Averill, Cincinnati Milling Machine Co.; Secretary E. J. Weller, General Electric; Panel Leader K. W. Stalker, General Electric; Norman Zlatin, Metcut Research Associates; R. C. Gibbons, Bendix Aviation; R. C. Morris, Thompson Products; Henry Albert, Republic Aviation

26 Exhibitors at Engineering Display

Aeroquip . . . Airtron . . . Allison . . . American Welding & Manufacturing . . . Bendix Products . . . Berkeley Scientific . . . Control Products . . . Elastic Stop Nut . . . Engis Equipment . . . Farrand Optical . . . General Controls . . . Hamilton Standard . . . A. W. Haydon . . . Hi-Shear Rivet Tool . . . Hughes Aircraft . . . Jack & Heintz . . . Lear . . . New York Air Brake . . . Resistoflex . . . Rosan . . . Scintilla Magneto . . . Stratos . . . Titeflex . . . United Aircraft Products . . . United States Steel . . . Vickers

Officials of New Willys Motors, Inc.


E. F. Kaiser


D. G. Roos

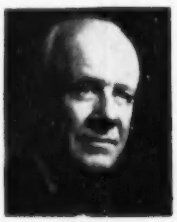

T. A. Bedford

EDGAR F. KAISER, president of Kaiser-Frazer Corp., has announced the purchase of the physical assets of Willys-Overland Motors, Inc., by Kaiser Mfg. Co., wholly-owned subsidiary of Kaiser-Frazer. The newly-acquired company will be named Willys Motors, Inc. Headquarters will remain in Toledo, Ohio.

Mr. Kaiser will be president and a director of Willys Motors. Among the vice-presidents of the new firm will be **DELMAR G. ROOS**, formerly first vice-president of Willys-Overland, and SAE President in 1934; and **THOMAS A. BEDFORD**, vice-president of Kaiser-Frazer Corp.

About

C. C. PEARSON has been named vice-president in charge of manufacturing of Beech Aircraft Corp., Wichita, Kans. Pearson was previously vice-president of operations of the Glenn L. Martin Co., and prior to that was with Douglas Aircraft Co. for 16 years.



E. J. COSFORD has been named president and managing director of Canadian Car and Foundry Co., Ltd., Montreal, Que. He had been vice-president in charge of sales for the past six years. Cosford was chairman of SAE's Montreal Section in 1951-52.

Z. C. R. HANSEN has been elected vice-president of the Diamond T Motor Car Co., Chicago. Hansen was formerly vice-president and general manager of Automotive Equipment Co., Portland, Ore. Before joining that company in 1944, he was with International Harvester Co. and its export subsidiary. Hansen is a past chairman of SAE's Oregon Section.

CLIFFORD E. PHILLIPS has been elected president and general manager of the R. M. Hollingshead Co. of Canada, Ltd., Toronto, Ont. He was formerly vice-president in charge of sales of the Perfect Circle Co., Ltd., Leaside, Ont. Phillips is a past secretary of SAE's Canadian Section and is currently president of the Canadian Automotive Wholesalers and Manufacturers Association.

DALE McKEE has been promoted to vice-president of engineering of the Baker-Lull Corp., formerly the Lull Mfg. Co., Bloomington, Ill. McKee has been chief engineer of the company since 1951.

WILLIAM J. BRINKMAN is now chief engineer of the Pressco Mfg. and Castings Corp., Chesterton, Ind. He was previously chief engineer of Aluminum Industries, Inc., Cincinnati.

THOMAS P. MAINZINGER has been named chief engineer of Attwood Brass Works, Grand Rapids, Mich. He was previously development engineer for Mechanics Universal Joint Division of Borg-Warner Corp., Rockford, Ill.

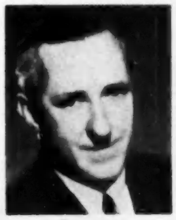
CHARLES E. DEXTER, JR., president of Liggett Spring and Axle Co., Monongahela, Pa., has been elected to the board of directors of the Four Wheel Drive Auto Co., Clintonville, Wis. He was also named to the company's executive committee.

E. V. LUCAS has been elected vice-president of Kingham Trailer Co., Inc., Louisville, Ky. He was previously sales manager of the company.

PAUL G. HOFFMAN, chairman of Studebaker Corp. and former Ford Foundation president, has been named to head a 15-million dollar study of civil liberties in the United States. Ford Foundation has set up the study as an independent corporation titled Fund for the Republic.

Members

Named Directors of White


Bauman


Fries

J. N. BAUMAN, vice-president—sales, and **V. W. FRIES**, vice-president—manufacturing of the White Motor Co., Cleveland, have been elected to White's board of directors. Bauman has been with White since 1922, and Fries since 1924.

GEORGE K. DREHER, formerly executive director of the Foundry Educational Foundation, Cleveland, Ohio, has joined the Waukesha Foundry Co., Waukesha, Wis., as manager of the casting division and a director of the company.

DWAIN E. FRITZ has been named executive vice-president of Royal Electric, Inc., Jamestown, Ohio. Fritz was formerly director of engineering and assistant to the president of Jack and Heintz, Inc., Cleveland, Ohio.

JOHN E. HEUSER, sales manager for the engine division of the LeRoi Co., has been elected vice-president of the Internal Combustion Engine Institute, Chicago.

JOHN A. CICALA has been named section chief at the dynanometer laboratory of Detroit Arsenal. Cicala was previously senior powerplant analyst for Chance Vought Aircraft Division of United Aircraft Corp., Dallas, Texas.

DR. W. I. E. KAMM has joined Stevens Institute of Technology, Hoboken, N. J., as research profesor of vehicle mechanics. He was formerly technical consultant for the Air Force at Wright-Patterson Air Force Base, Dayton, Ohio.

RICHARD A. PETERSON is now chief of the aircraft powerplant engineering section of the CAA's 3rd region in Chicago, Ill. Peterson was formerly liaison aircraft project officer for the Air Force at Wright-Patterson Base, Dayton, Ohio.

G. H. B. DAVIS has joined the Standard Oil Development Co., Linden, N. J., as coordinator of marketing services and contacts. Davis was previously assistant manager of marketing development for Standard Oil Co. (New Jersey), of which Standard Oil Development Co. is an affiliate.

JAMES H. DAVIDSON has been promoted to general manager of the Clinton Chain Saw Division of Clinton Machine Co., Clinton, Mich. Davidson was recently named director of sales and service of Clinton's Engine Division, and before that was assistant to the president.

JOHN D. WILLIAMS has been elected vice-president and general manager of Rollway Bearing Co., Inc., a subsidiary of Lipe-Rollway Corp., Syracuse, N. Y. Williams holds the same positions in Lipe-Rollway Corp.

C. S. DAVIS, JR., has been elected to the board of directors of Borg-Warner Corp., Chicago. Davis is president and general manager of the Norge Heat Division of Borg-Warner at Kalamazoo, Mich.

LEONARD A. STEWART has been appointed director of engineering of the automotive division of Motor Products Corp., Detroit. Stewart has been with Motor Products since 1950, and prior to that was chief engineer of the American Coach and Body Co., Cleveland, and chief body engineer for Mack Truck Co., Allentown, Pa.

C. E. HOLTSINGER, JR., has been named assistant to the general manager of Pratt and Whitney Aircraft Division, East Hartford, Conn., to coordinate the non-technical aspects of the Division's nuclear propulsion program for the Air Force and the Atomic Energy Commission. Holtsinger was formerly general manager of Clearwater Lincoln-Mercury Co., Clearwater, Fla.

New Vice-Presidents of Chrysler Corp.


Woolson


Newberg

L. I. WOOLSON, president of DeSoto Division of Chrysler Corp., and **W. C. NEWBERG**, president of Dodge Division, have been elected vice-presidents of the corporation.

Woolson, who joined Chrysler Corp. in 1928, was named president of DeSoto last year after having served as chief resident engineer, factory manager, operating manager, and vice-president. He has also been chief engineer of Plymouth. Newberg first joined Chrysler in 1933 as a test driver and mechanic. He became chief engineer of the Dodge Chicago B-29 engine plant in 1942. After the war he was elected president of the Airtemp Division. He returned to Dodge as vice-president in 1950 and was elected president in 1951.

Retirements at Chrysler Corp.

Weckler

Wallace

Breer

HERMAN L. WECKLER, vice-president, general manager and a director of Chrysler Corp., **DAVID A. WALLACE**, president of Chrysler Division, and **CARL BREER**, a director and formerly executive engineer and director of research, have retired from Chrysler Corp.

Weckler has been with Chrysler since 1932 and has been a vice-president since 1937. He has also served as vice-president and general manager of DeSoto Division and as president of Dodge Division. Breer was executive engineer and director of research from the time the company was organized in 1925 until retiring in 1949. He has been a member of the board of directors since 1937.

Thomas

Moxey

DR. CHARLES L. THOMAS has been named associate director of the research and development department of Sun Oil Co., with headquarters in Marcus Hook, Pa. **JOHN G. MOXEY, JR.**, was named an assistant director of the department. Thomas was previously manager of Sun's research laboratory at Norwood, Pa., and Moxey was manager of the automotive laboratory at Marcus Hook.

Bancroft

Effman

RICHARD BANCROFT has been named manager of the castings division of Perfect Circle Corp., Hagerstown, Ind. Succeeding Bancroft as manager of the engineering division is **KARL EFFMAN**, formerly chief research engineer. He will be responsible for the administration and coordination of the various engineering sections.

R. G. LeTOURNEAU, pioneer and leader in the earthmoving equipment industry, is planning to devote part of his time as a consultant on development and research for the newly-formed LeTourneau-Westinghouse Co., a subsidiary of Westinghouse Air Brake Co.

Westinghouse Air Brake recently bought the earthmoving and related business of R. G. LeTourneau, Inc., of which LeTourneau is the founder and president. The Westinghouse purchase included all the company's fixed assets and machinery at Peoria, Ill., and Toccoa, Ga., and its interest in an Australian subsidiary. The Vicksburg, Miss., and Longview, Texas, plants will remain with LeTourneau, Inc., which will continue to produce special products, including land-clearing equipment, not related to earthmoving.

ELMER ISGREN, who was executive vice-president of R. G. LeTourneau, Inc., will continue as executive vice-president of LeTourneau-Westinghouse. He has been with the firm since 1930.

J. D. DICKERSON is now chief metallurgist of the Midland, Pa., works of Crucible Steel Co. of America. Dickerson was formerly chief metallurgist for Republic Steel Corp. in Buffalo, N. Y.

EDMUND T. PRICE, president and general manager of Solar Aircraft Co., has announced the building of an all-faiths chapel on the company's grounds in San Diego, Calif. The chapel will be built by employees with materials furnished by the company; it was designed by Donald Campbell, La Jolla architect, without charge. Price, who conceived the chapel, hopes it will provide "a refuge of quiet in our busy, noisy lives."

BENJAMIN P. BAER has been appointed senior designer for the Truck and Coach Division of General Motors Corp., Pontiac Mich. He was previously connected with the Caterpillar Tractor Co.

PAUL G. WILLER is now chief engineer of Clement Engineering, Inc., Janesville, Wis. Willer was formerly with the diesel engine division of Fairbanks, Morse and Co., Beloit, Wis.

GEN. JAMES H. DOOLITTLE, vice-president of Shell Oil Co., has been named chairman of the United Defense Fund, which finances the U.S.O. and five other agencies benefitting servicemen.

ALEX R. ANDRE, chief engineer of Cockshutt Farm Equipment, Inc., Bellevue, Ohio, has been recalled to active duty with the Naval Air Corps. Andre joined the company, then the National Farm Machinery Cooperative, Inc., in 1951, and was promoted to chief engineer when Cockshutt purchased the firm. During World War II, he served on a carrier in the Pacific theater for three years.

RICHARD C. CLINE has joined the engineering staff of the Gabriel Co., Cleveland, as research engineer. Cline was previously with Ford Motor Co. of Canada, Ltd., in the chassis engineering unit.

W. B. HURLEY, who retired from the Detroit Edison Co. early this year, just returned from an extensive trip through the South. Hurley is now applying his more than 40 years of production, plant operation, and industrial development experience in industry by taking on consulting engineering work, with headquarters at 321 Rivard Blvd., Grosse Pointe, Mich. He is a registered professional chemical, electrical, and mechanical engineer in Michigan. Hurley was SAE vice-president for production in 1939 and has been an active member of the SAE Production Activity Committee since that time.

BEN D. MILLS has been promoted to assistant general manager of the Aircraft Engine Division of Ford Motor Co., Chicago, Ill. Mills was previously assistant plant manager of Ford's Kansas City aircraft plant.

BENJAMIN J. DeSIMONE, formerly director of engineering for United Metal Industries, Santa Monica, Calif., is now with the Precision Development Co., Inc., in Santa Monica.

L. E. GRUBB has been appointed general superintendent of the Huntington, W. Va., works of the International Nickel Co., Inc. He has been general superintendent of the company's Bayonne, N. J., works since 1942.

WILLIAM P. BARNES is now assistant professor of mechanical engineering at the University of Utah. Barnes was previously a research scientist at the Lewis Flight Propulsion Laboratory of NACA in Cleveland, Ohio.

ROY E. EDWARDS has joined the Schlumberger Well Surveying Corp., Houston, Texas, as senior mechanical engineer. He was formerly project engineer for the Western Co., Houston, Texas. Edwards is a past secretary and treasurer of Mid-Continent Section.

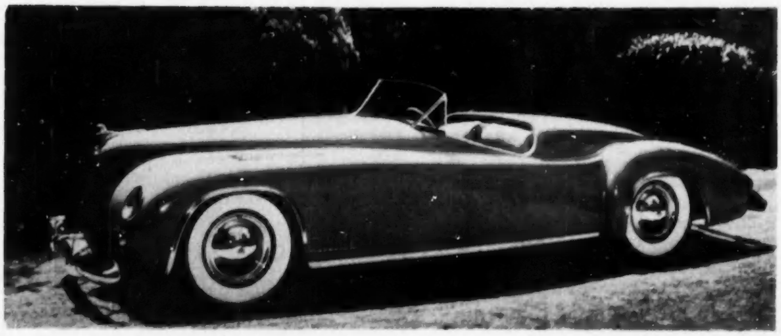
FRED C. PATTON recently retired as general superintendent of passenger service for Pacific Electric Railway Co. in Los Angeles, and plans to use his 30 years of experience in fleet safety work as a consultant. Patton joined Pacific Electric as a ticket agent in 1918. A member of SAE since 1927, Patton has been active in both national and local SAE affairs. He is a past chairman of Southern California Section and a past councilor.

GEORGE BENNETT has been elected executive vice-president, general manager, and a director of the Harold F. Howard Co., Detroit. Bennett has been vice-president and chief engineer of the company since 1948.

ARTHUR M. SWIGERT, JR., vice-president in charge of production of Universal Products Co., Inc., Detroit, has been elected to the board of directors of the company.

S. FLOYD STEWART has joined Jack and Heintz, Inc., Cleveland, as assistant to the president. He will devote most of his time to new product planning. Stewart was previously executive vice-president of the Arma Corp., Brooklyn, N. Y., and has served as president of Leece-Neville Co.

EDWARD GRAY has been named assistant to the general manager of the coach and aircraft division of the White Motor Co., Cleveland, to take charge of the division's production. Gray was previously director of quality control and chief inspector at White's truck division. He joined the company in 1947 as assistant to the quality control director.



H. STERLING GLADWIN, JR., of Maverick Motors recently announced that the Maverick car, shown above, would be built in limited production. The reinforced plastic body also may be purchased as a separate unit. It is said to fit any 121- to 128-in. wheelbase chassis. This includes many Hudsons, Buicks, Packards, and any Cadillac from 1936-53 in the 61 series, says Gladwin.

GEORGE D. SIMONDS, director of engineering for the Four Wheel Drive Auto Co., and his son, **GEORGE D. SIMONDS, JR.**, product design engineer for the Ansul Chemical Co. The younger Simonds was a member of the SAE Student Branch at the University of Wisconsin before graduating in February, 1952.

SAE Fathers and Sons

THOMAS S. KEMBLE (M '11) and **EDWARD D. KEMBLE** (M '43) were snapped as they were chatting at the SAE National Production Meeting in Cleveland. The elder Kemble is with the White Motor Co. His son, Ed, is manufacturing manager, Air Conditioning Division, General Electric Co., and also meetings vice-chairman of the SAE Production Activity Committee.

JOHN C. ESTABROOKE is now supervisor of maintenance for Hertz Driv-Ur-Self Stations, Inc., in Kansas City, Mo. He was previously with the New York National Guard at Camp Smith, N. Y.

E. WAYNE HORTON, JR., has joined Hamilton Standard Division of United Aircraft Corp., Windsor Locks, Conn., as aerodynamics engineer. He was previously field engineer for the H. H. Robertson Co., Boston.

WARNER T. TABB, formerly engineer with International Plainfield Motor Co., Plainfield, N. J., has retired and now lives in Mount Holly, Va.

JAMES G. STAFFORD is now manager of technical research for Supertest Petroleum Corp., Ltd., London, Ont. He was previously automotive sales engineer for Imperial Oil, Ltd., Leaside, Ont.

HARVEY S. FIRESTONE, JR., chairman of the Firestone Tire and Rubber Co., has been named national chairman of United Nations Week 1953, Oct. 18 to 24, by the American Association for the United Nations.

ROBERT TWELLS, vice-president of the Electric Auto-Lite Co., has been elected treasurer of the American Ceramic Society.

A. F. HAILEY is now sales promotion manager for Trailmobile Canada, Ltd., Toronto, Ont. Hailey was formerly editor of Bus and Truck Transport magazine in Toronto.

D. S. BRUCE, who was field representative for the AP Parts Co., Toledo, has been promoted to territory manager in the Northern California area, with headquarters in San Carlos, Calif.

E. S. INGHAM has joined the fastener division of the Simmons Co., Albany, N. Y. For the past seven years, Ingham has been manager of the Albany branch of Wheels, Inc.

J. F. AUSTIN is now Great Lakes regional manager for Engine Life Products Corp. in Chicago. He was previously with Deluxe Products Corp., LaPorte, Ind.

JOHN R. HULL, who was previously district engineer for the Torrington Co. in Detroit, is now at the company's headquarters in Torrington, Conn.

N. J. BECK is now with Douglas Aircraft Co., Santa Monica, Calif., as research engineer in the powerplant analysis group. He was formerly senior research engineer for GMC's Research Laboratories Division, Detroit.

EARLE F. CLEGG, who was district manager for the California Oil Co. in New Orleans, La., has been transferred to the company's Chicago offices.

MAJ. JULIUS F. KOETSCH of the U. S. Marine Corps is now stationed at the David W. Taylor Model Basin, Carderock, Md., as high speed division officer. Major Koetsch recently completed courses at the University of Minnesota.

CHARLES F. KETTERING of General Motors will receive the NSPE Award of the National Society of Professional Engineers at the Society's annual meeting in Daytona Beach, Fla., June 18-20.

ROGER O. BAY has been named sales manager of the tool division of Bonney Forge and Tool Works, Allentown, Pa. Bay was previously sales manager of the automotive division of Cleveland Pneumatic Co.

SAE Members Are Saying . . .

In reply to the question "If you were buying jet or turboprop airplanes, would you be willing to buy British makes or must you stick to the manufacturers of this country?" **Ralph S. Damon,** president of Trans World Airlines, said, at a luncheon of the Aviation Writers Association:

"All the airplanes we now have are fitted with SAE standard bolts, nuts, electrical and hydraulic connections and similar fittings. British airplanes would, of course, be equipped with British equivalents, many of which are not SAE standards, even though the parts may serve identical purposes. To me as an operator this presents a very substantial obstacle, and while I would have to evaluate any specific situation at the time, I feel generally that standardized threads and fittings are so important that others things being approximately equal, I would want to stay with one set of standards."

• • •

"I am reinforced in my conviction that we can look forward to good business throughout the year of 1953. Underlying this confidence in the future are certain basic economic factors: the increase in consumer spending resulting from population growth and high employment; the phenomenal rise in number of households; and the high level of home building, business investment, and Government outlays." . . . **Harlow H. Curtice,** president, General Motors Corp., at a testimonial luncheon given by General Motors dealers.

"We do not increase our standard of living by simply utilizing more people to produce goods with the same old methods and tools. We increase the amount of things that you and I and the rest of us want by increasing the ability of individuals to produce more with the same effort and in the same period of time." . . . **R. J. Emmert,** executive in charge of facilities and processes staff, General Motors Corp., in talk before the Industrial College of the Armed Forces, Washington, D. C.

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"Jet transports now under development will be able to compete favorably with present commercial airliners in terms of both range and payload, in addition to surpassing them in speed." . . . **Edward C. Wells,** vice-president in charge of engineering, Boeing Airplane Co., in addressing annual meeting of the Airport Operators Council, Kansas City.

F. S. BASTER, right, vice-president of engineering of the White Motor Co., Cleveland, received the Case Institute of Technology citation for achievement in automotive engineering from Dr. T. Keith Glennan, president, at the Case 75th anniversary convocation celebration.

WILLIAM B. SHIMER has been promoted to master mechanic at DeSoto Division of Chrysler Corp., Detroit. Shimer has been assistant master mechanic since 1950. He first joined Chrysler Corp. in 1948.

EDWARD C. HOENICKE, general manager of the foundry division of Eaton Mfg. Co., Detroit, has been elected to the board of directors of the American Foundrymen's Society, Chicago. Hoenicke is also president of the Gray Iron Research Institute, Columbus, Ohio.

DORMAN B. DICKERSON, JR., has been named manager of production equipment design and equipment construction shop of P. R. Mallory and Co., Inc., Indianapolis, Ind. He was formerly co-owner and manager of the Dickerson Engineering Co., Detroit.

HERMAN H. MESICK has been named assistant manager of the Portland, Ore., regional office of Dodge Division of Chrysler Corp. He joined Dodge in 1946 as district truck manager in Syracuse, N. Y., and has served as regional truck manager in the San Francisco and Los Angeles regions for the past five years.

BURKE M. HYDE, JR., has been promoted to assistant chief engineer of Chrysler's Delaware Tank Plant, Newark, Del. He was formerly liaison engineer for Chrysler in Elkton, Md.

NICHOLAS WOLOFSKI has joined the Stubnitz Greene Spring Corp., Adrian, Mich., as product engineer. He was formerly product engineer for the Murray Corp. of America, Detroit.

RICHARD ALLCHIN is now sales engineer for the Rotor Tool Co., Cleveland, and has established a branch office for the company in Baltimore, Md. Allchin was previously sales engineer for Harris Products Co., Cleveland.

W. S. RAINVILLE, JR., has returned to his post as director of research for the American Transit Association, New York City, after serving as director of the equipment and research division of the Highway Transport Department, Office of Defense Transportation, Washington, D. C., and with other government transportation agencies.

On April 10, Rainville was given an Award for Exceptional Service by James K. Knudson, defense transport administrator. The citation praised "his broad experience and understanding of transportation problems as related to the national mobilization activity . . . His ability, his industry, and his untiring devotion to duty were of incalculable value to the mobilization effort of the nation."

LOUIS F. PIETZ has retired from the Fort Wayne Transit Co., Fort Wayne, Ind., and now lives in Nokomis, Fla. Pietz has been an SAE member since 1923.

KENNETH W. CUNNINGHAM, JR., has joined Sun Oil Co. as motor products salesman in Blawnox, Pa. He was previously an automotive maintenance officer in the Air Force at Wolters Air Force Base, Texas.

E. J. BRADBURY is now with the motor truck engineering department of International Harvester Co., Fort Wayne, Ind. He was previously chief engineer of International Harvester Co. of Canada, Ltd., Chatham, Ont.

LOUIS M. FERENS has joined Republic Aviation Corp., Farmingdale, N. Y., as senior research engineer. He was formerly mechanical engineer for Standard Oil Development Co., Linden, N. J.

CLIFFORD R. FEILER is now with Pandjiris Weldment Co., St. Louis, Mo., as new product development engineer. He was formerly with McDonnell Aircraft Corp. in St. Louis, and is currently chairman of the program committee of SAE's St. Louis Section.

ROBERT A. OSTLIND has joined the Heeb Co., Madison, Wis., as salesman. He was previously district manager for the Thermoid Co. in Chicago.

DONALD W. WANDERER is now a process engineer for GMC's Electro-Motive Division, LaGrange, Ill. He was formerly an ensign in the U.S. Coast Guard in Washington, D. C.

CHARLES H. PHANEUF is now senior stylist on special product operations for Ford Motor Co., Dearborn, Mich. He was previously stylist for Packard Motor Car Co., Detroit.

ELDON J. SHOREK has joined the Detroit Engine Division of Kaiser-Frazer Corp. as quality control engineer. Shorek was previously instructor of electronics and fire control equipment for the Ordnance Corps at Fort Monmouth, N. J.

ROBERT C. BIVONA has joined American Airlines, Inc., in Tulsa, Okla., as engineer. Bivona was previously brake engineer for Bendix Products Division of Bendix Aviation Corp., South Bend., Ind.

WALTER A. KNITTLE is now a research engineer on guided missiles and rocket powerplants for North American Aviation, Inc., Downey, Calif. Knittle was formerly mechanical research engineer for United Aircraft Corp., East Hartford, Conn.

MILTON A. PHILLIPS has been named industrial district manager for the Fram Corp. in Houston, Texas. He was previously in the railroad sales department at the corporation's headquarters in Providence, R. I.

ROY C. NORTON, JR., has joined the Bower Roller Bearing Co., Detroit, as application engineer. He was formerly assistant to the executive engineer at International-Plainfield Motor Co., Plainfield, N. J.

C. EARL SUTTER is now with the Chicago Rawhide Mfg. Co., Chicago, Ill., as design engineer. He was previously sales engineer for General Tire and Rubber Co., Detroit.

JOHN A. MOSLEY has rejoined the Cleveland Graphite Bronze Co., Cleveland, as product engineer, after a year's service with the Army at Fort Monmouth, N. J.

H. W. BECKER has been transferred from General Motors Continental, Antwerp, Belgium, to General Motors Overseas Operations in Detroit.

JOHN M. SCHNETZLER has joined Hayes Aircraft Corp., Birmingham, Ala., as powerplant engineer. He was formerly field engineer for Wright Aeronautical Division of Curtiss-Wright Corp. in Los Angeles, Calif.

V. L. BOLAND is now on special assignment for the National Pressure Cooker Co., Eau Claire, Wis. He was previously with Plymouth Motor Division of Chrysler Corp. in Maywood, Calif.

J. S. SNELL is now a sales representative for GMC's Truck and Coach Division, in New York City. He was previously with the ACF-Brill Motor Co., Philadelphia, Pa.

NICHOLAS G. KOPPINGER is now works manager for Multi-Hydromatic Welding and Mfg. Co., Detroit, Mich. Koppinger was formerly supervisor of tools and fixtures for Briggs Mfg. Co., Detroit.

A. R. PARILLA is now with the propeller division of Curtiss-Wright Corp., Caldwell, N. J. Parilla was formerly division head for M. W. Kellogg Co., Jersey City, N. J.

RUTH E. DeWALD has been promoted to technical specialist in charge of the missile branch technical library of Chrysler Corp.'s engineering division, Detroit. Mrs. DeWald was previously technical assistant in Chrysler's engineering library. An active member of Detroit Section, she has served on the reception committee and as associate editor of the monthly "Supercharger."

ROBERT F. LYBECK, manager of aviation sales for Esso Standard Oil Co., in Boston, Mass., has been elected chairman of the Boston Evening Clinic drive. Lybeck is a past chairman of New England Section.

ELROY PENNER has joined the hydraulic division of Sundstrand Machine Tool Co., Rockford, Ill. Penner was previously test engineer for Pacific Pumps, Inc., Huntington Park, Calif.

Obituaries

HAROLD A. HICKS

Harold A. Hicks, section chief of the body and structures laboratory of Ford Motor Co., died April 12 at the age of 58. He was stricken with a cerebral hemorrhage several days earlier.

Hicks earned a bachelor's degree in mechanical engineering and a master's in automotive engineering at the University of Michigan, and taught there before entering the Army as an aeronautical engineer in 1917.

He joined Ford in 1919, designing and developing chassis components, speed boats and airplanes. He was given many special assignments by Henry Ford while the company was producing the Ford tri-motor plane.

In 1932 he joined the Chrysler Corp., returning to Ford in 1946. In his post with the Ford engineering staff, he was highly respected as a teacher as well as a supervisor.

Hicks is survived by his wife and two sons, one a body draftsman for Ford and one a Marine corporal, and one grandson.

FRED H. RAGAN

Fred H. Ragan died Jan. 13 at the age of 68. He was consulting engineer for the aircraft bearing division of the Detroit Aluminum and Brass Corp.

In the early days of World War II, Ragan developed precision aircraft bearings for Bohn Aluminum and Brass Corp. After the close of the war, he was commissioned a colonel and was one of a group of specialists who travelled to Germany to study German manufacturing methods.

Earlier, he was associated with the Cleveland Graphite Bronze Co., Columbia Axle Co., and the Gemmer Mfg. Co. He patented a widely used mechanical power press and many other automotive devices.

Ragan is survived by his wife, two sons and two grandsons.

C. A. SHEPARD

C. A. Shepard was killed Feb. 20 when his car struck a railroad overpass abutment. He was 54.

Shepard was president of the Inter-State Oil Co., Kansas City, Kans., a company founded in 1887 by his father. The company's plant was destroyed by flood in 1951, and Shepard was directing construction of a new plant at the time of his death.

A native of Kansas City, Shepard attended Kansas City Junior College and the University of Missouri. He was a charter member and director of the Independent Oil Compounders Association and a member of the Oil Men's Club of Kansas City, as well as of SAE.

He is survived by his wife, a sister and a brother.

NEWS OF SAE

CHICAGO . . .

. . . gets '54 National Production Meeting.

THE SAE National Production Meeting, reborn in Cleveland this past March, moves on to Chicago for its 1954 appearance. Already plans are under way to launch this Meeting, with top notch production men set to head its operation.

SAE Vice-President for Production Neil Petersen reports that his invitation to serve as sponsor of the Meeting has been accepted by A. W. Phelps, chairman of the board, Oliver Corp. General chairman of the Meeting is Ralph C. Archer, vice-president of manufacturing, International Harvester Co.

The Meeting is scheduled for March 29-31, 1954, at the Drake Hotel. The first day will consist of Production Forum panels, with technical sessions

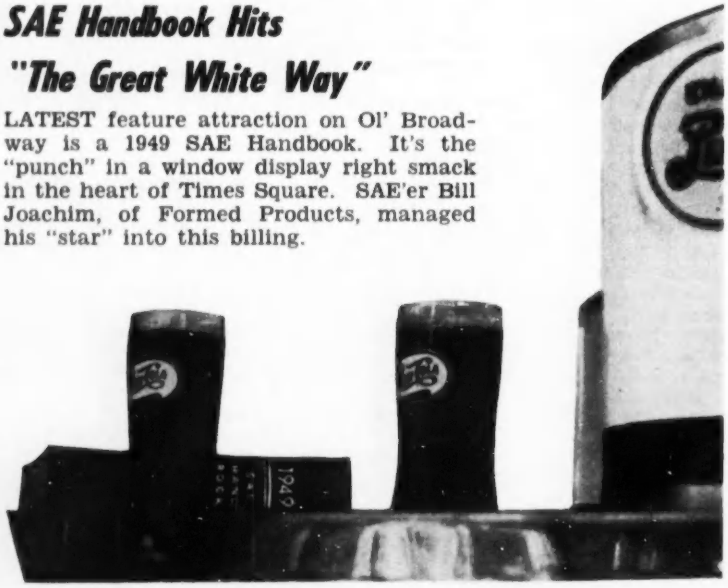
A. W. Phelps

and plant trips planned for the other two days. The Meeting is slated for Council approval this month.

The meeting in Cleveland last March was the largest SAE National Production Meeting ever held. The SAE Production Activity Committee agreed that it is worth repeating, in the light of the interest in it.

SAE Handbook Hits "The Great White Way"

LATEST feature attraction on Ol' Broadway is a 1949 SAE Handbook. It's the "punch" in a window display right smack in the heart of Times Square. SAE'er Bill Joachim, of Formed Products, managed his "star" into this billing.



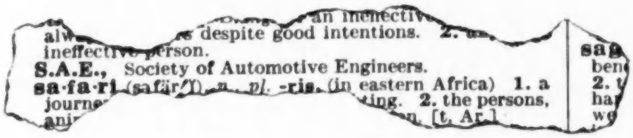
COE Tractors

THE cab-over-engine tractor for highway operations is a pretty hot subject in transportation circles these days. Several truck builders recently introduced COE models and fleet men are giving them serious consideration.

The SAE Truck & Bus Activity Committee is sponsoring a session on the subject at the SAE National Transportation Meeting in Chicago next November. Both truck engineers and fleet operators are on the program.

"SAE" in Dictionary

"SAE" has taken its place as an officially recognized word in the English language. SAE is listed alphabetically by initials ("S.A.E., Society of Automotive Engineers") in the main section of the 1952 edition of the American College Dictionary.


despite good intentions.
ineffective person.
S.A.E., Society of Automotive Engineers.
sa·fa·ri (safär'i), n., pl. -ris. (in eastern Africa) **1.** a
journey ... **2.** the persons,

National Meetings . . .

Meeting	Date	Hotel
	1953	
INTERNATIONAL WEST COAST	Aug. 17-19	Georgia Hotel, Vancouver, B. C.
TRACTOR and PRODUCTION FORUM	Sept. 14-17	Hotel Schroeder, Milwaukee
AERONAUTIC MEETING and AIRCRAFT ENGINEERING DISPLAY and AIRCRAFT PRODUCTION FORUM	Sept. 29-Oct. 3	Hotel Statler, Los Angeles
INTERNATIONAL PRODUCTION	Oct. 29-30	Royal York Hotel, Toronto
TRANSPORTATION	Nov. 2-4	Conrad Hilton, Chicago
DIESEL ENGINE	Nov. 3-4	Conrad Hilton, Chicago
FUELS & LUBRICANTS	Nov. 4-6	Conrad Hilton, Chicago
	1954	
ANNUAL and ENGINEERING DISPLAY	Jan. 11-15	The Sheraton-Cadillac and Hotel Statler, Detroit
PASSENGER CAR, BODY, and MATERIALS	March 2-4	Hotel Statler, Detroit

SAE Section Meetings

Cleveland—June 19

Lake Forest County Club, Hudson, Ohio. Dinner 6:30 p.m. Golf outing and dinner—entertainment after dinner.

Dayton—July 2

Walnut Grove Country Club. Dinner 7:00 p.m. Golf Jamboree. Tee-off time 1:00 p.m.

San Diego—June 12

Casper's. Dinner 7:30 p.m. Social meeting. Presentation of plaque to Section Chairman F. E. McCreery, Jr.

Texas Gulf Coast Section—June 12

Varsity Room, Ye Old College Inn. E. L. Asch—Power Steering.

The following Sections will not hold any meetings in June:
- Northwest
- Mid-Michigan

The following Sections will not hold any meetings during the summer months:

Colorado	Twin City
Northern California	Washington
Philadelphia	Williamsport

This is not a complete list of all Section Meetings. It includes only those meetings for which we have received sufficient advance notice to permit listing.

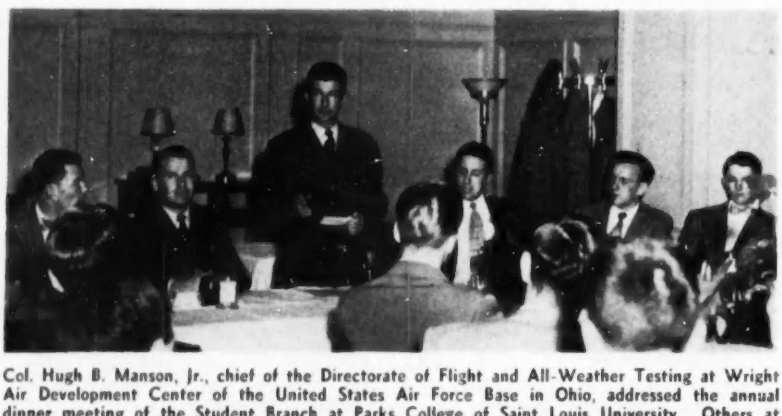
SAE Student News

Parks College

On March 26 the fifth annual banquet of the SAE Student Branch at Parks College of Aeronautical Technology was held, with an attendance of 60 members plus a number of guests. Speaker of the evening was **Col. Hugh B. Manson, Jr.**, chief of the Directorate of Flight and All-Weather Testing, Wright Air Development Center, Dayton, Ohio. In this capacity, he is responsible for the flight testing and evaluation of various aircraft and components designed and developed for the United States Air Force.

The title of Manson's talk was "The Designing and Testing of Aircraft." With the use of slides he gave a brief outline of the advantages and disadvantages of the straight, swept and delta wings at subsonic and supersonic speeds. He then stressed the need for standardization of various parts of airplanes such as the cockpit especially in different models of the same basic design. He went on to explain the various phases of testing that each airplane must go through before it is accepted for tactical use by the Air Force.

Colonel Manson spoke mainly on the phase that he is best acquainted with—all-weather testing. He stated that present day aircraft still are not able to operate under all types of weather conditions, especially where conditions of icy runways exist. In conclusion, he stated that engineers have a great responsibility in designing aircraft that have a maximum safety factor. After finishing his talk he answered various questions put to him by the members present.



Col. Hugh B. Manson, Jr., chief of the Directorate of Flight and All-Weather Testing at Wright Air Development Center of the United States Air Force Base in Ohio, addressed the annual dinner meeting of the Student Branch at Parks College of Saint Louis University. Others at the head table from left to right: James Lewellen, faculty advisor for the Branch; Maj. Allison P. Gentry, associate professor of air science and tactics, AF ROTC at the College; Colonel Manson; Fred Weisman, president of the Branch; Richard Russell, treasurer and Dan Howe, secretary

Detroit Institute of Technology

On March 11, **Dr. T. A. Boyd** of GMC's Research Laboratories Division was guest speaker at the monthly luncheon of the D.I.T. Student Branch.

Dr. Boyd gave an illustrated lecture on "The Revolution on the Railroad," showing the rapid switch from the steam locomotive to the new diesel-electric locomotion in the past 20 years.

Thirty students and five faculty members were his interested listeners.

College of the City of New York

On March 26, **Norman G. Shidle** lectured at a joint meeting of the SAE and ASME on "Technical Writing." Shidle is editor of the SAE Journal and author of the recent book, "Clear Writing for Easy Reading."

Shidle stressed the fact that clear thinking precedes clear writing. He pointed out that the person who says, "I know what I want to say but I don't know how to say it," doesn't know what he wants to say; often a person first really learns something when he is forced to write about it.

He pointed out that, for technical and commercial reports, the main thought should be put right up front, so the busy executive can readily find out what his subordinates wish to tell him. The statement having been clearly made, the body of the report will then prove how that statement was arrived at. The reader may stop after the first paragraph, but he will have the idea.

It was these preceding statements that were thought most important by the students. Shidle's lecture itself was an excellent example of the principles he outlined and greatly helped the students to benefit from what he said.

—**Emanuele G. DeMarco**

Fenn College

Lamson and Sessions Co., manufacturers of bolts, nuts, screws and pins, played host to the Fenn Student Branch with a tour through its Cleveland plant on Jan. 22. The tour was complemented by a panel session and buffet supper during which members presented questions for discussion by the panel. The questions were principally concerned with production and quality control methods used in the plant, and the associated production methods problems involved.

The panel, composed of supervisors of various functions within the plant, dealt with the questions put them very adequately, each member of the panel taking up those points applicable to his particular specialty. Members of the panel were: **Ray Gatz**, assistant factory manager; **Leo Lesnak**, personnel director; **John Pekar**, chief expediter; **Omer Wade**, general foreman; and **Ed Williams**, superintendent of the carbide department.

Some unique problems in production and quality control are presented when there are about 40,000 possible shape, dimensional, and material variations per year coupled with an output of six million units per day. It was learned,

first, that from the standpoint of production control, economic lot sizes are maintained for any particular combination of die type, material, and machine operations employed by a cumulative order arrangement and adequate stock reserves on standard items. Special orders can then be given proper consideration, and more easily scheduled. In reference to quality control, answers from the panel indicated that the plant is largely under statistical control utilizing both x-bar and r and percentage defective charts. At present, at least a 1.2 A.O.Q.L. is maintained.

—**Charles B. Goldman**, Field Editor

Academy of Aeronautics

On March 13 the Student Branch of SAE at the Academy of Aeronautics took a field trip to the propeller division of the Curtiss-Wright Corp., Caldwell, N. J.

The day started miserably with an unusual March rain. Most of the students attending live in New York, and the drive to the plant was pure confusion: mud up to the running boards, broken springs, and creased fenders. But everyone arrived on time and anxious to proceed through the enormous buildings.

The students were divided into four groups. Two plant guides were assigned to each group. The tour was planned so that the first thing shown was the rough steelplate made of a chrome-nickle-molybdenum alloy. The class then moved along to see the 2000-ton presses that do the plate blanking and blade shell forming.

The guides then took the group to see the blade rough welding, which is a combination of manual and automatic welding. This is the method by which the camber and thrust sides of the blades are joined.

The students witnessed the blade shank upset and blade blowup procedures. In the latter process, 1100 lb per square inch of nitrogen is forced into the blade to give it its shape. This process takes only 20 seconds.

The students next witnessed the section where pellets of copper alloy are brazed to the inner portion of the leading and trailing edges of the prop blade. This gives the blade a fine fairing fillet.

A section of the shop that made all the members of the inspection tour feel a little more at home was that devoted to Magna-Flux machines and X-ray equipment. Each blade was thoroughly inspected to insure perfection of every square inch of steel.

At this point, the blade is zinc plated, painted, and readied for assembly. The many questions asked by the students were ably answered by the capable guides.

The group then moved across the street to the testing laboratories. In this building, new guides were introduced and the tour continued.

The weary but still interested students moved through each of the testing labs: mechanical fatigue, hub tension, whirl booth, electrical, and electronic fatigue. A welcome chance to sit down presented itself when a short movie was shown.

The information gathered was an invaluable aid to the class, especially since Curtiss electric propellers are used at the Academy.

The tour, which took about four hours, was arranged through the cooperation of Frank Tedesco, faculty adviser for the Student Branch at the Academy of Aeronautics, Walter Hartung, director of training at Curtiss-Wright, and Mr. LaBarre of Curtiss-Wright.

—**Stanley Portnoy**

Academy of Aeronautics Students Tour Idlewild

Members of the Student Branches of SAE and IAS at the Academy of Aeronautics toured Idlewild Airport last Nov. 12, in a tour arranged by the Port of New York Authority. At left, students watch a demonstration of the instrument landing display board. At right, they get an overall view of the field from the control tower

SAE Section Meetings

D. P. Barnard is Coffee Speaker at Milwaukee; Section Prepares for Summer with Paper on Outboards

• Milwaukee Section

P. S. Myers, Field Editor

May 1—A talk by Past President **D. P. Barnard** and a paper by **W. C. Conover**, chief engineer of Outboard Marine and Mfg. Co., followed a full afternoon that included a trip through the Harley-Davidson Motor Co. and fishing movies by Outboard Marine and Mfg. Co.

Speaking after dinner, Dr. Barnard talked of "engineering myopia," or short sightedness, and the part SAE plays in reducing it through exchange of information. It was not so long ago, he pointed out, that it was proved that the internal combustion engine was impractical—"that such a device could only melt itself down in the first few seconds of operation. A little later it was also proved beyond contest that powered man-carrying flight was impossible, if for no other reason than for the lack of a sufficiently powerful lightweight engine."

"I believe that the key to the last five decades of development is the use of objective scientific research in pathfinding for engineering," Dr. Barnard said. "Most of this research and development work has been of an intensely competitive nature . . . However, competitive research is not quite the whole story . . . Today, research men working in competitive organizations do not lock themselves in cells—either figuratively or actually."

"The interchange of some information and ideas between organizations is necessary—even between those who are direct competitors . . . It is in this field of cooperative exchange of appropriate information that SAE fits into the great picture of applied research and scientific development."

Tracing the engineering achievements of the last half century, Dr. Barnard concluded, "Today every SAE member can be proud of his Society's contributions over 50 years of applied research—research such as is symbolized by the golden year of powered flight."

The main paper of the evening was by **W. C. Conover**, chief engineer of Outboard Marine and Mfg. Co., who talked on "The Engineering Aspects of Outboard Motors." Conover traced the development of the outboard motor, starting with a propeller chain driven from a Curtis motorcycle motor. In 1907 the Waterman engine introduced a gear-driven propeller and in 1909 "Ole" Evinrude introduced the first commercial production model, a single-cylinder, 900 rpm model with battery ignition. In 1914 Evinrude introduced magneto ignition, in 1915 the automatic reverse, and in 1916 underwater exhaust. Kaban introduced twin-cylinders, also in 1916. In 1921 the Johnson outboard motor entered the field featuring light weight (35 lb), high speed (2300 rpm), pivot steering and reverse, a cavitation plate, and tilting to clear underwater obstructions. Further improvements introduced in the 1920's by various manufacturers were aluminum pistons, propeller protection, slip clutch, die cast aluminum parts, variable pitch propellors, and the co-pilot feature that tended to keep the motor and boat going in the same direction.

In the late 20's and early 30's the rotary valve was introduced and engine speeds went up to 7000 rpm. In 1934 the reed valve was introduced. These and other advances improved idling and mid-range performance. Following the war years the industry standardized the gasoline-oil ratio, introduced separate tanks, gear shifts, and improved magneto performance.

Conover also pointed out the many engineering reasons why two-cycle engines are used in outboard engines, including light weight, high speeds, simple construction, ruggedness, simplicity of and low costs of manufacturing. He then discussed the design procedure for the engine. This involves first of all determining the duty for which the engine is to be used and from this obtaining the desired thrust curve. When the thrust curve has been established the propeller, engine, and gear ratio combination can be chosen to give the desired thrust curve.

After explaining other engineering features, such as the method of speed control and the problems involved in obtaining smooth idling and good scavenging without excessive by-passing of fuel, Conover ended by pointing out that the industry is growing rapidly and that many new developments will undoubtedly be forthcoming.

During the question and answer period it was brought out that while additive oils usually keep the engine cleaner they may also shorten plug life. It was also mentioned that small amounts of lead in the gasoline probably do not cause spark plug fouling but that large amounts undoubtedly contribute to fouling. Conover stated that they have not investigated different scavenging arrangements too thoroughly as yet but that the present deflector piston do have construction advantages. In reply to a question, he said that the same engines are used in salt and fresh water service. Overcooling was brought out as an operation problem, particularly when trolling. Correct circulation control of water utilizing the thermal siphon effect has been found more satisfactory than thermostats or heat exchanges.

Before the dinner meeting, members toured the Harley-Davidson Motor Co. plant, and saw motorcycles put through their paces by test riders and by specially-built test rigs that simulate road conditions. Movies supplied by Outboard Marine, showing Rainbow trout caught and fried, aroused healthy appetites for dinner.

John F. Chellman (right) of International Harvester Co. chats with technical chairman D. T. Saunders at the March 26 meeting of Oregon Section at which Chellman spoke on the crawler tractor in the construction industry

Section Tours Milling Machine Plant

• Cincinnati Section

Edward B. Lohaus, Field Editor

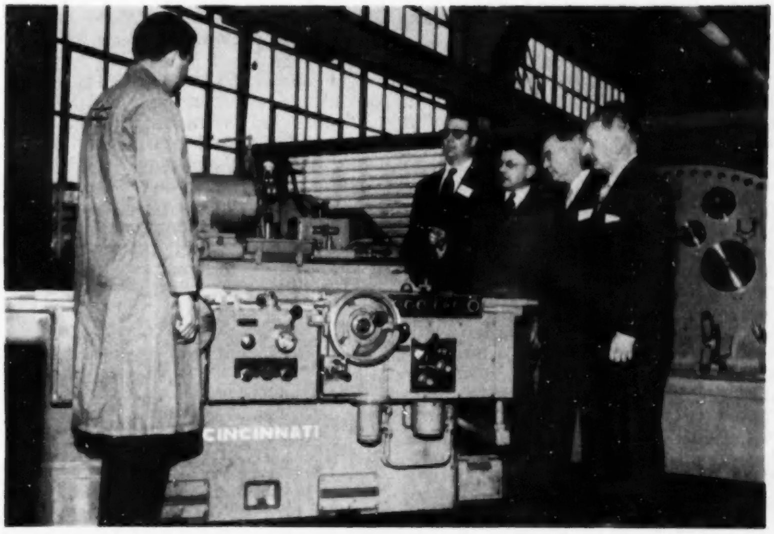
April 27—Forty-eight members of the Cincinnati Section enjoyed an informative tour of the Cincinnati Milling Machine Co.'s large Oakley plant.

Guests were divided into groups of four and each group was assigned a guide. This arrangement enabled each guest to ask questions and to learn a great deal about the operation of this very modern plant.

The tour included Plant I, where many of the latest developments in milling and grinding machines were observed in operation, assembly, and run-off; Plant II, where large surface broaching machines for use on automotive cylinder blocks were being assembled and run-off; the ultra-modern foundry where five different types of iron are poured; and the Flamatic Laboratory where the spectacular new Flamatic machine was demonstrating selective hardening jobs on items such as automotive crankshafts, camshafts, and cams for torque converters. The Hydroform machine in Plant I attracted much attention with its ability to deep-draw sheet-steel parts in one operation, using a male die and a rubber diaphragm under pressure acting as the female die.

Special guides met the group at the Products Division and conducted them through the plant devoted to manufacturing Precision Grinding Wheels and Cimcool Cutting Fluid.

The tour was arranged by Lape Thorne, chairman of the Cincinnati Section, and R. S. Marshall of Cincinnati Milling Machine Co.



Members of Cincinnati Section inspect a new Cincinnati 6 x 18 Hydraulic Grinding Machine with automatic sizing, used for shaft grinding and transmission parts, on the April 27 tour of Cincinnati Milling Machine Co. Left to right are: R. S. Marshall, in charge of technical service for Cincinnati Milling Machine; Charles M. Reesev, advertising manager of the company; Section Chairman Lape W. Thorne; and Fred W. Biederman, chief engineer of Biederman Motors Corp.

Describes Uses Of Crawler Tractor

• Oregon Section

D. T. Saunders, Field Editor

March 26—The crawler tractor owes its versatility to the allied equipment that makes it a universal tool, according to **John F. Chellman**, supervisor of industrial power service training for the International Harvester Co.

Liberally illustrated with slides, the paper demonstrated the track layer's importance in military operations; in the reclamation of worthless land; in push loading, pipe laying, and the many other heavy duty jobs in the wide field of construction.

No piece of equipment, however, is self-sufficient. Chellman pointed up this fact graphically by depicting how 15 TD14-A's, among other heavy duty machines, were transported by airplane to Labrador for mining operations over 350 miles of barren and, in some places, impassable wasteland.

Detroit Section Honors "Old Timers"

• Detroit Section

George J. Gaudaen

May 4—The Rackham Memorial Building echoed with automotive reminiscences as the Detroit Section honored its 25-years-or-longer SAE members. One hundred and eighty automotive veterans, out of 278 on the rolls, were present to receive their certificates of recognition from SAE President **Robert Cass** and to hear SAE General Manager **J. A. C. Warner** discuss "SAE Men in Action."

An added attraction for the large crowd which attended the meeting was a behind-the-scenes glance at the recent Yucca Flats atomic tests provided by **A. L. Haynes.** Haynes, assistant head of the Ford Motor Co. engineering research department, is chairman of the SAE Advisory Committee to the Federal Civil Defense Administration.

Representing those who have been SAE members for 35 or more years, E. W. Winans, formerly with Federal Motor Co. and now retired, received a framed gold certificate from President Cass. Victor Jantsch, retired, formerly with GMC Truck & Coach, similarly received a framed silver certificate for the 25-years-and-over members. At the conclusion of the meeting individual certificates were presented to all the veterans present.

Preceding the certificate presentation, Warner described how these and other "SAE Men of Action" have achieved for the Society international recognition and esteem. He said SAE standards and recommended practices are used and imitated in practically every country in the world. All American cars and planes in use today, he further stated, have some components made according to SAE.

This has been achieved, he feels, because SAE has always encouraged "everybody to get into the act." The members have responded with such willingness that today over 3,000 of them are active on technical committees. This is in addition to those who serve on the various sectional activities. Warner noted that Detroit Section members have been among the most active in SAE affairs. He cited as an example the fact that 20 national presidents have come from this section since its inception in 1911.

Warner concluded his talk by narrating a film, "SAE Men in Action," prepared by the SAE Staff. The film brought back many fond memories to the old timers present as it featured pictures of the members at meetings during the 20's and 30's. The men representing the future SAE were also shown in sections of the film devoted

to meetings of the **Detroit Section** Junior and Student Activities.

Prefacing the presentation of the certificates, Cass noted that it was a revelation to him when he came from England to find the freedom of action and thought which went into SAE work. A result of this has been, he believes, that SAE standards have never cramped but continually stimulated the automobile industry. SAE members working freely have contributed considerably to the defense effort both in World War II and in the current emergency. He felt that one of the strongest weapons which this country has lies in the SAE meetings and forums which serve to stimulate engineering thought.

Discussing the atomic tests, Haynes reported that at the request of the federal government the SAE committee was asked to work with the FCDA to determine the protection which would be offered to the occupants of motor vehicles from the effects of an atomic blast and to determine the blast effects on the cars themselves. He said that through the cooperation of various groups, 51 new and used vehicles were obtained for the tests. A preliminary post-test analysis revealed little damage to chassis and engine components. He reported that all the cars which could be driven before the tests were found to be in a drivable condition afterwards.

Haynes said that a more detailed analysis of the test results is now being undertaken. The information obtained from this analysis will be presented in a committee report to be given on June 9 at the SAE Summer Meeting in Atlantic City. Films of the tests will also be shown at that time.

During the business session, it was announced that K. E. Coppock, assistant chief engineer, Fisher Body Division, General Motors Corp. has been elected Detroit Section chairman for the next season. He succeeds P. H. Pretz of Ford Motor Co.

Describes New Cessna Model

• Wichita Section

Jay H. Whoolery, Field Editor

April 29—**Jerry Gerties**, chief engineer, commercial aircraft, for Cessna Aircraft Co., gave a talk on "The Design Development of the Cessna 180." His talk was illustrated with colored slides.

Gerties compared the new Cessna 180 with their older Model 170. The new aircraft has a cruise of 160 mph against the 140 mph of the 170. It grosses 2550 lb against the 2200 lb for the 170. The design stresses simplicity. The general dimensions of the aircraft are somewhat similar to those of the 170.

The Model 180 has a 225 hp Continental engine, while the Model 170 has a Continental 145 hp engine. Increase in speed was picked up through the use of flush riveting, making the horizontal stabilizer adjustable over the use of the tab control on the 170. It is a four-place cabin land monoplane and can be set up for seaplane operation.

Preliminary designs were tested at the Wichita University.

Temperature Problems Limit Turbine Development

• Twin City Section

D. D. Hornbeck, Field Editor


D. D. Hornbeck

April 8—"Current gas turbine design problems are more structural than aerodynamic," according to **Reeves Morrison**, research engineer for Pratt & Whitney Division of United Aircraft Corp. While greater thermodynamic efficiency in the gas turbine could be gained through use of higher temperature gases against the turbine blades, the melting point of suitable metals places definite restrictions on the practical efficiency.

Temperature levels of 1500 F are possible when using turbine blade material of largely nickel or stellite. Certain metals are non-forgeable and non-machinable, though, making it necessary to utilize a casting process in forming the turbine blade. The only machining necessary is then confined to the blade root attachment point.

While ceramics have been considered as a possible material for turbine blades due to their ability to withstand higher temperatures, the extreme brittle characteristics make them too critical and too difficult to use—for when one blade in the turbine disintegrates, it can clean out the entire inside of the turbine along with it.

In some German gas turbines, air-cooled blades have been used, but such a luxury is likely to prove too costly for practical use. Any restriction of the miniature air channel in the interior of the blade would allow excessive temperatures beyond the temperature endurance limit of the metal blade, and prompt loss of the blade would result.

Use of molybdenum, which has good strength at higher-temperature levels, has been made possible through coating the moly with another material of lesser strength, but with oxidation resistance to overcome the tendency of moly to oxidize easily at high temperatures. Any flaking, scaling off, or cracking of the protector coating will similarly allow the immediate oxidation of the entire blade.

The miracle metal, titanium, may be highly effective in reducing the weight of the compressor, since titanium has twice the strength/weight ratio of most metals.

Since no great improvements in turbine metals are immediately foreseeable, since turbine design is now in a high state of development, and power losses in gearing are small, the greatest improvement seems to be in integrating the right combination of these factors into the most effective gas turbine unit.

Lists Advantages Of 12-Volt System

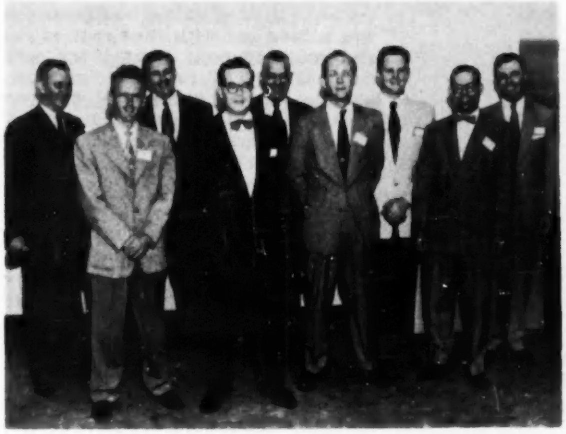
• Western Michigan Section

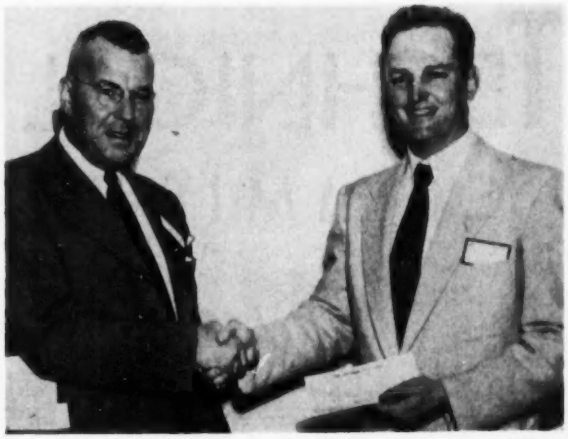
A. L. Maring, Field Editor

April 21—The April meeting of the Western Michigan Section was held at Martini's Restaurant near Grand Rapids, Mich. This was the annual meeting held in the Grand Rapids area instead of at Muskegon, headquarters for the Western Michigan Section.

William Purchas, Jr., chief engineer of GMC's Diesel Equipment Division, was technical chairman and introduced the main speaker. "The 12-Volt Electrical System" was the subject discussed by **Herman L. Hartzell**, assistant chief engineer of Delco-Remy Division of GMC. Hartzell gave a fine talk illustrated with slides showing the development of the 12-v electrical system and pointing out its advantages. The 12-v electrical system is at present used on three General Motors cars and on one Chrysler car. It is expected that more cars will change over to the 12-v system every year.

Hartzell pointed out that the increased voltage is needed on the bigger cars only, at present, and is needed for the ignition and not for all the added electrical gadgets now on the modern automobile. The old 6-v system was being taxed to its capacity on the newer modern cars and as soon as the spark plugs were slightly worn the ignition voltage was not sufficient for proper operation. Delco-Remy Division did nearly all of the test work on actual test cars and did not rely on dynamometer testing. It was pointed out that too often the dynamometer





Student speakers took the floor at the April 17 meeting of Northern California Section. Left to right are: Prof. C. J. Vogt of the University of California; Leland Mosher, Stanford student; Thomas H. Hardgrove, Student Branch adviser at California State Polytechnic College; James Lindquist, University of Santa Clara student; Section Chairman James E. Glidewell; Victor Kebely, University of California student; Terry W. Carr, California State Polytechnic College student; Prof. E. S. Starkman, University of California, Section student activities chairman; and Dean Harold Hayes of California State Polytechnic College. At right, student Terry Carr gets a handshake—and a check—from Chairman Glidewell for his paper on the use of alcohol as a fuel, judged best of the four papers

and actual useage did not agree too closely.

Hartzell summarized his talk by pointing out these advantages of the 12-v system: 1. better ignition; 2. higher generator output; and 3. faster cranking speed. The 12-v system operates with the same distributor, the same size coil, the same size generator and the same size cranking motor. A larger battery is needed, but the size increase is only 5% and the energy storage capacity is increased by 30%. All in all, Hartzell concluded, the 12-v system should keep you going down the road rather than standing in a service station.

The meeting closed with a film of last year's 500 Mile Indianapolis Race.

Student Papers Highlight Meeting

• Northern California Section

K. L. Kipp

April 17—The April meeting of the Northern California Section was held at the California State Polytechnic College. The technical session consisted of four student speakers competing for prizes as a part of the Annual Student Paper Contest.

For those who made the trip to San Luis Obispo from the Bay area, activities started with a well-conducted tour of the campus facilities. Following a dinner at the campus cafeteria, the technical session was held under the direction of Professor E. S. Starkman of the University of California, student activities chairman.

Leland O. Mosher of Stanford University was the first contestant of the evening and presented a paper on "The Fuel Economy of High Compression Spark Ignition Engines." Mosher developed from a theoretical basis the fuel economy of a given size engine for several different compression ratios at a given set of operating conditions. Comparing these economics with the current costs of fuels which would satisfy the octane requirement of the engine, he concluded that compression ratios in the order of 10:1 could not be justified from an economical basis.

A very interesting paper on "Design Considerations for an Automotive Steam Engine" by **James Lindquist** of the University of Santa Clara followed. Lindquist presented the general arrangement for a four-cylinder steam engine and the design problems involved in its use. With the use of cheaper "Bunker C" type fuels under the boiler, the author believed the cost of operation would be less than for current internal combustion engines. Other advantages over a gasoline engine, such as more favorable torque characteristics and no need for a transmission, were also pointed out.

A paper on "The Ram Jet, Its Uses and Limitations" was presented by **Victor Kebely** of the University of California. His interesting presentation highlighted the differences between this type engine and others such as the turbojet. Original data which he had obtained in the labroatory on the relationship of fuel-air ratio required to maintain combustion as a function of air velocity was also presented. The development of flame holders for the ramjet was described as more of an art than a science at the present time.

The concluding paper was by **Terry Carr** of California State Polytechnic College on "The Use of Alcohol as a Fuel." The large interest in "hot rod" cars and so-called "drag racing" has led to the use of various fuels such as alcohol and many novel ways of modifying engines and fuel systems. Carr covered the fuel system modifications which he has made on an engine in order to most effectively use alcohol as a fuel.

Excellent presentations were made by all contestants, presenting the judges with a difficult task of selecting a winner. The final decision awarded first place to Carr, followed by **Kebely**, Lindquist and Mosher.

Chromium Plating Stretches Ring Life

• Salt Lake Group

J. P. Bywater, Field Editor

April 20—Research utilizing radioactive materials and the Geiger counter have played a tremendous part in the development of the piston ring used in the internal combustion engine, **A. J. Weigand** of Perfect Circle Corp. told members and guests.

Like most engineering problems, the

Continued on Page 108

TECHNICAL COMMITTEE *Progress*

Effects of Nevada Atom Test On Cars Studied by SAE Group

ONE big fact seems to have come out of the atomic device test at Yucca Flats, Nevada, last March 17. If you are in or near your car at the time an A-bomb hits, and you survive the blast, you'll be able to get into your car and drive away from the area as soon as the police or local Civilian Defense authorities permit.

That's what the SAE Advisory Committee, cooperating with the Federal Civil Defense Administration, found after examining the 50 test cars right after the explosion.

Most of the cars one mile or more away from "Ground Zero," location of the bomb test tower, could be started after the test. In a large majority of the cases, engines, chassis, axles, gears, electrical equipment, and cooling systems came through in operating condition. What really took the beating were the bodies and glass.

The Committee, headed by A. L. Haynes, of Ford Motor Co., reported that the greatest visible damage to the cars was caused by shock or blast. Damage from heat wasn't nearly as great. Shock waves from the blast caused the mechanical damage.

The wave moves with the speed of sound, causing first a forward pressure and then a suction.

Members of the Committee as well as Atomic Energy Commission and FCDA personnel anticipated considerable fire damage to close-in cars; but there was very little.

One of the few cars seriously burned was a used car with fiber seat covers and recapped tires, located one mile from Ground Zero. The car was gutted. Its glass was melted, and two tires on the tower side burned up, while the other front tire blew out.

Closed Windows

The cars which had all the windows closed showed the most noticeable effect from general shock. In every such case, regardless of distance from Ground Zero, the roof and one or all door panels were caved in . . . some roofs as much as 10 to 15 in., enough to deal a damaging and perhaps fatal blow to any occupant who remained upright. In certain cases mannequins' heads were crushed or they were decapitated.

Generally speaking, glass and tires withstood shock and heat well, except well up in the forward area.

Bodies took a terrific beating. Only cars turned over, except a Post Office truck, were at the one half mile radius. The wooden body of a station wagon was kindling wood.

In most of the cars beginning with the three-quarter mile arc, the engines started and the cars moved forward and backward under their own power.

Heat, Pressure Damage

A general damage effect on many cars was the loosening of the chrome trim strips at the car exterior belt line. Some cars showed rubber flash around the windows and doors. There were a few cases of grazed tires, some cases of paint scorching, and one or two cases of scorched upholstery.

The SAE Committee began its preparations for the atomic test early in the year. It developed forms for pretest and after-test data. Members of the Committee arrived in Nevada a week before the test and set up their

Before

After

At left is one of the test cars before the test, which was in front of one of the two test houses, about 7500 ft from Ground Zero. Its doors were closed during the test and a mannequin was seated inside. At right is the car after the test. The right side of the windshield was blown in. The paint finish was cracked, some trim was blown off. The top was caved in 10 to 12 in. and fractured the heads of both mannequins in the front seat. Both right doors were caved in. The trunk door was blown open and the latch was sheared off

headquarters in Las Vegas. They maintained constant liaison with officials of the FCDA and Atomic Energy Commission.

The Committee recently prepared an interim report on its test findings which it submitted to the FCDA.

Serving with Chairman Haynes on the Committee were: R. B. Alexander, Packard Motor Car; William Christensen, Nash-Kelvinator; Dr. V. B. Corey, Willys-Overland; N. F. Hadley, Chrysler; Dr. E. J. Martin, Research Laboratories Division, GMC; M. J. Muzzy, GM Proving Ground; W. W. Smith, Studebaker; and A. D. Wagner, Hudson Motor Car.

Members of the SAE-FCDA Advisory Committee are shown here with AEC security officers at the entrance to the Nevada Proving Ground, Mercury, Nevada. They are (left to right): Dr. E. J. Martin, N. F. Hadley, R. B. Alexander, Dr. Victor B. Corey, AEC officer, M. V. Muzzy, AEC officer, W. Waits Smith, Chairman Alex L. Haynes, AEC officer, W. Christensen, and R. C. Sackett

Group Digs Into Earthmover Test Code

TWO down and six to go—that's how matters stand with the 8-part "tractor" test code being prepared by Subcommittee XII of the SAE CIMTC.

Just recently finished are test codes that will permit rating reserve tractive ability and vehicle drag of self-propelled construction and industrial machines. In the hopper—and expected to be done in time for publication in the 1954 SAE Handbook—are test codes for determining fuel consumption, speed and acceleration, brake ability, steering loads and turning, grade ability, and tilt limitations.

Initiated at the request of the Corps of Engineers, this project is aimed at helping the Corps fulfill its desire to have an "Evaluation Manual" for all of its rubber-tired and crawler tractors.

Euclid Road Machinery's H. L. Rittenhouse is chairman of this SAE Construction and Industrial Machinery Technical Committee group.

Proposed Standard for Refrigeration Fittings

THE SAE is planning to recommend for adoption as an American Standard a revised and expanded version of the SAE Standard for refrigeration fittings to be used with single-thickness annealed copper flared tubing.

The proposed standard is now being circulated among 17 other interested organizations for their review and approval.

The SAE Tube, Pipe, Hose, and Lubrication Fittings Committee did the revise job.

SAE Tool Steel Standards Score with Heat Treaters

THE following editorial appeared in the January-February 1953 issue of "Metal Treating," official journal of the Metal Treating Institute which is the national trade association of commercial heat treaters:

"An important but relatively quiet and unpublicized activity has been developing recently which is of major importance to every heat treater and every heat-treating department or commercial plant. This is the standard classification of tool steels being established by the Society of Automotive Engineers. The Society deserves the support and gratitude of everyone involved in the heat treating industry for this step for it will now become possible for all tool steel users to order their materials by an established designation which will signify not only analysis but specific reactivity of the material as related to heat treatment.

"One of the most frequent and regular of the many headaches confronting the heat treater has been the indefiniteness or failure of the customer or the engineering department or machine shop to furnish definite facts about the material being supplied for treatment.

"Without such knowledge, of course, or with the vague designation so frequently offered, major errors can and have developed. In such instances, disastrous failures and heavy losses can occur. These, naturally, end up in violent arguments revolving around, 'I thought it was this' and 'You should have known it was that.'

"It is obvious that these headaches can be eliminated by the proper adoption of the Society of Automotive Engineers tool steel designations as applied to heat treatment. Plan to make use of these now and insist that the materials sent to you for heat treatment be clearly designated in accordance with these standards."

Four Performance Charts Printed for Hydrodynamic-Drive Vehicles

STANDARDIZED forms are now available for reporting performance of vehicles equipped with hydrodynamic drives. They are SAE Forms HE, HF, HG, and HH.

Form HE is reproduced as Fig. 1. Forms HF and HG are similar except that Form HF has scales suitable for engines up to 800 hp and Form HG has scales suitable for engines up to 1800 hp. Form HH has the grid but has blanks instead of scale numbers so that users may label scales themselves for special applications.

All four forms have the grid printed on the back of the sheet so that erasures of datum points will not destroy the grid. The paper is sufficiently transparent to show the grid through to the face of the sheet and to reproduce well. Sheet size is 11 × 16½ in.

The SAE Hydrodynamic Drive Committee, which developed the forms, warns that: "It is essential that engine data used in preparing these curves precisely describe the power delivered to the transmission as installed in the vehicle; that is, all corrections for accessories, air temperature, air cleaners, mufflers, and fans be considered. The words 'installed net' torque and horsepower are intended to express this condition."

Individual forms are available through the SAE Special Publications Department at 40¢ each form to members and 80¢ to nonmembers. Quantity prices for both members and nonmembers are: 3 to 99 forms, 30¢ each; 100 to 499 forms, 25¢ each; 500 or more forms, 20¢ each.

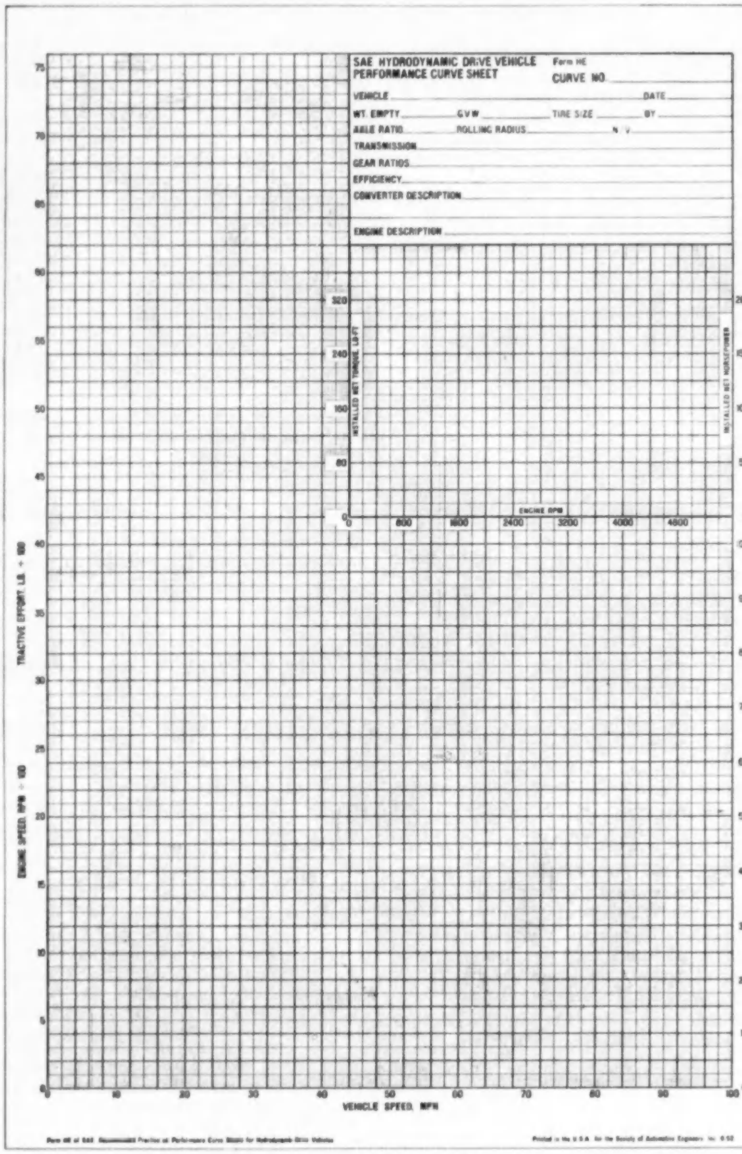


Fig. 1—SAE Form HE—Hydrodynamic Drive Vehicle Performance Curve Sheet

Scope Increased for Joint Drafting Group

THE scope of the Joint Aeronautical-Automotive Drafting Subcommittee has been expanded to cover two new assignments:

1. To develop common standards for the aero and auto industries on all phases of geometric tolerancing (that is, drawing information to specify parallelism, concentricity, flatness, perpendicularity, and the like, with regard to associated surfaces).

2. To develop an SAE position in regard to drafting standards for use in work with the ASA Sectional Committee on Standards for Drawings and Drafting Room Practice (Y-14). Y-14 is now engaged in the job of trying to develop a U.S. position that will be used in later negotiation with the British and Canadians, when the three countries get together for a conference to try to develop international standards in regard to drafting room practice.

Originally, the Joint Subcommittee was set up, with S. B. Elrod as chairman, to study and interpret the British Drafting Standard 308. The group did such a notable job that O. E. Kirchner, chairman of the Aeronautical Drafting Committee S-1 and W. A. Siler, chairman of the Automotive Drafting Standards Committee, with the blessing of the Technical Board, decided to give it the additional assignment.

The standardizing of geometrical tolerancing is a very important phase of drafting standardization. Moreover, it is felt that the success of the subcommittee in this area will certainly lay the groundwork for other joint standardization projects between the two industries.

In anticipation of this increased working load, S-1 and the Automotive Committee have each appointed three additional members to serve on the Joint Subcommittee.

The new participants from S-1 are: P. G. Belitsos of General Electric,

Joseph Stannard of Pratt & Whitney Aircraft, and W. B. Billingham of Hamilton Standard.

Those appointed by the Automotive Drafting Committee are: James A. Boxall of Ford, C. M. Buhl, Budd Co., and Leon DeMause, Cadillac Tank Division.

The original members of the committee, S. B. Elrod, chairman, J. Gerardi, University of Detroit, and George McCain of Chrysler, and Paul V. Richards of Wright Aeronautical, will continue to serve.

What's Coming in SAE Aero Materials Specs

NINE proposed new and revised specifications are being circulated to industry for review and comment by the SAE Aeronautical Materials Specifications Division. Copies of these specifications are available from the SAE Aeronautical Department.

Thirteen new and revised specifications have been approved recently by the SAE Technical Board. Eleven specifications have been cancelled.

The proposed specifications are:

- AMS 4756—Solder 97.5Pb-1.5Ag-1Sn;
- AMS 5085—Steel Sheet and Strip 0.47-0.56C (SAE 1050);
- AMS 5036C—Steel Sheet and Strip, Aluminum Coated, Low Carbon (Aluminum Killed);
- AMS 5040F—Steel Sheet and Strip, Low Carbon (Aluminum Killed) Deep Forming;
- AMS 5542D—Alloy Sheet, Corrosion and Heat Resistant Nickel Base-15Cr-7Fe-2.5Ti-1(Cb + Ta)-0.7Al;
- AMS 5613C—Steel, Corrosion and Moderate Heat Resistant, 12.5Cr;
- AMS 5616B—Steel, Corrosion and Moderate Heat Resistant 13Cr-2Ni-3W;
- AMS 5667D—Alloy, Corrosion and Heat Resistant Nickel Base-15Cr-7Fe-2.5Ti-1(Cb + Ta)-0.7Al;
- AMS 5668D—Alloy Sheet, Corrosion and Heat Resistant Nickel Base-15Cr-7Fe-2.5Ti-1(Cb + Ta)-0.7Al.

The cancelled specifications are:

- AMS 3223B—Synthetic Rubber;
- AMS 3288—Felt, Upholstery;
- AMS 3291—Felt, Kapok;

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- AMS 3385—Markers, Ignition Cable, Non-Metallic;
- AMS 3602—Plastic Sheet and Plate, Electrical and Heat Resistant;
- AMS 3665—Fabric: Coated Nylon;
- AMS 5033—Steel Wire, Zinc Coated;
- AMS 5730—Steel, Corrosion and Heat Resistant;
- AMS 5760—Alloy, Corrosion and Heat Resistant;
- AMS 6253E—Steel, Carburizing;
- AMS 6480A—Steel, Nitriding.

The approved specifications are:

- AMS 2670B—Copper Furnace Brazing, Carbon and Low Alloy Steels;
- AMS 3197D — Synthetic Rubber Sponge Chloroprene Type—Soft;
- AMS 3198D — Synthetic Rubber Sponge Chloroprene Type—Medium;
- AMS 3199D — Synthetic Rubber Sponge Chloroprene Type—Firm;
- AMS 3226C, AMS 3227C, AMS 3242A —Synthetic Rubber;
- AMS 3607A—Plastic Sheet and Plate;
- AMS 3615A—Plastic Tubing; AMS 4610F—Brass, Free Cutting;
- AMS 3810A—Tape, Adhesive, Cloth Back;
- AMS 4062B — Aluminum Tubing, Seamless;
- AMS 4071D—Aluminum Alloy Tubing, Hydraulic;
- AMS 6381A—Steel Tubing, Mechanical;
- AMS 6428—Steel; AMS 6434—Steel;
- AMS 7452D—Bolts and Screws, Steel Alloy.

Dryseal Thread Group Considers Fine Series

TWO new subgroups have been set up by the Dryseal Pipe Thread Subcommittee of the SAE Screw Threads Committee.

One of these groups is investigating the possibility of developing a fine series of pipe threads. Its membership is as follows: Otto Hoelzel of Eastern Machine Screw Corp., chairman; R. G. Chambers, Buick Motor Division; P. E. Rose, Ford Motor Co.; P. G. Schulz, Crane Co.; and R. F. Holmes, AC Spark-Plug Division.

For a starting point, R. F. Holmes, chairman of the Dryseal Pipe Thread Subcommittee, presented the group with a chart for 27-pitch Dryseal threads from ½- to 1-in. diameter. (Present pitch in this size range is 14.) It was stated that experience with such threads had shown that they have very good sealing properties for some applications.

The other group was organized to clarify the text of the Dryseal Pipe Threads Standard. In recent years, minor modifications have been made. Now the idea is to study the text as a unit to make it as clear and logical a presentation of the subject as is possible. It will also allow the detailed technical information to be removed from the text and placed in appendices.

This group consists of: Harold Fisher of Bendix Products, chairman; C. F. Schaening, GMC; C. M. Wright, Chrysler Corp.; and W. A. Hertel, Weatherhead Co.

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selection of piston rings for any given engine is a compromise of several different factors. Two of the major factors are abrasive wear resistance and scuff resistance. More abrasive wear resistance can be obtained by employing surface hardening of a special cast iron, but the additional problems in ring manufacture result in a slightly improved ring at a much higher cost. Fully-hardened alloy cast iron has shown considerable promise and may be a practical means of improving abrasive wear resistance.

The scuff resistance of piston rings can be improved by plating the ring faces with chromium. Further improvement can be effected by interrupting the surface of the chromium just as it can on gray iron rings. Chromium plating on the faces of compression rings does allow the use of narrower and therefore more scuff resistant rings with no sacrifice of abrasive wear resistance over somewhat wider gray iron rings. In fact, the narrower chromium plated rings will usually have better abrasive wear resistance than the wide gray iron rings.

Discussion brought out that engine rebuilders can help in maintaining the maximum efficiency designed for the engine by observing the recommended practices developed by manufacturers over years of research.

The Salt Lake Group has elected the following officers for the ensuing year: Richard Ostlund, engineer for Eimco Corp., chairman; William B. Littreal, chemical engineer, Utah Oil Refining Co., vice-chairman; and Wayne M. Gersen, E. I. duPont de Nemours and Co., secretary-treasurer.

Trailers Designed For Minimum Maintenance

• Salt Lake Group

J. P. Bywater, Field Editor

April 6—The economic importance of the trucking industry as related to our average American family and the rapid development the truck trailer has played in improving the industry was brought out by **K. W. Tantlinger,** vice-president in charge of engineering for Brown Trailers, Inc.

The reduction of dead weight to permit maximum payloads while abiding by the laws regulating gross vehicle weight is being solved by the truck trailer manufactures in the use of high-strength, light-weight alloy metals and advanced structural engineering. During each of the last two years the truck trailer industry has produced some 65,000 trailers. In the past two years about 55% of all trailers were van trailers, the type Tantlinger talked about.

The heavy, hard pulling, unsafe trailer of a few years back has been replaced with a completely functional, carefully designed and esthetically beautiful trailer, Tantlinger said. The old sheet-metal covered, wood-framed trailer bodies, which continually required repair and disintegrated in the event of an accident, are rapidly disappearing from our highways. They are being replaced with gleaming all-aluminum units, into which extra strength has been designed.

The truck trailer plays the roll of an orphan in the maintenance programs of many truck operators, since it is usually left at a dock to be unloaded and reloaded, while the favored tractor is taken to be fueled and lubricated. When loaded again, the trailer is picked up by a freshly serv-

iced tractor and whisked away to another destination where it is again dropped for unloading and reloading, and where it again often fails to receive any attention. In recognition of these facts, the modern truck trailer has been designed to provide excellent service in spite of the minimum attention bestowed upon it.

With an increasing requirement being placed on the trucking industry to transport almost everything that is manufactured, grown, bought, or sold, the industry is faced with an ever-broadening challenge. The truck trailer industry has risen to the occasion and is providing an ever-improving product to meet and exceed requirements, Tantlinger concluded.

Canadian Section Holds Windsor Meeting

• Canadian Section

F. G. King, Field Editor

April 17—A very successful annual Windsor meeting was held in the Prince Edward Hotel, with about 400 members and guests in attendance. The meeting was under the chairmanship of J. A. Dykes, regional vice-chairman for Windsor district.

Canadian Automotive Trim, Limited, and L. A. Young Industries of Canada were hosts at a reception preceding the dinner, which was made still more pleasant by a musical entertainment by Miss Margaret Bradford (Miss Canada), accompanied by an accordionist.

The speaker of the evening was **Dr. Kenneth McFarland**, educational consultant and lecturer for General Motors. He gave an inspiring and very interesting talk on "The U in Industry."

Forecasts Leveling Of Engine Horsepower

• Detroit Section

W. F. Sherman, Field Editor

April 13—The eleventh annual regional meeting of the Detroit Section was held in Toledo, Ohio, at the Commodore Perry Hotel. The meeting was preceded by a tour through the Champion Spark Plug plant and a pre-dinner reception sponsored by several Toledo companies.

Victor G. Raviolo, Ford Motor Co. executive engineer, was the speaker on the subject of "Future Automotive Powerplants." An audience of about 450 crowded the ballroom to hear him.

"About every ten years there is a peak in the engine-horsepower curve," Raviolo said. "Then there is a leveling off, a period of steady growth, and a periodic repetition of the curve." He expressed the belief that this periodic curve is related to tooling amortization. The industry has just completed the bulk of a retooling program (or in some cases is now completing it), so we now have a period of slower development ahead. In the engines which are giving 0.5 to 0.6 horsepower per cubic inch today, we have integrated most of our present knowledge of engines, Raviolo declared. Ahead of us there is a 7 or 8% increase due to better compression ratio and combustion, 5 to 10% from breathing, and maybe 10% from valving. These will be the slow types of gains made over the next several years.

The next big problem, he asserted, is obtaining larger engines without greater weight or cost. "We will not be looking for horsepower per cubic

inch but will be seeking more cubic inches per pound and more cubic inches per dollar," he forecast.

Compression Ratio

An increase in compression ratio from 7:1 to 12:1 gives a 20 to 30% gain in economy and increases thermal efficiency from 27% to 33%. Gasoline economy increases from 18 to 22½ miles per gallon. But we can make these gains only as fast as the petroleum industry can give better fuels economically, Raviolo said. He sees the possibility of 100 octane gasoline by 1960 and a 10:1 compression ratio at that time. Our rate of increase in compression ratio has been stepped up so this is possible, he pointed out. However, he sees a leveling off at 10:1 compression ratio because gas pressures continue to increase, even though efficiencies level off at higher compression ratios. (At 10:1 we expect 39% thermal efficiency and at 14:1 we expect 41%, so the speaker sees 10:1 as the "pay-off" limit.)

As to engine types, Raviolo cited the obvious advantages of V-8's, but said that six-cylinders-in-line have virtues of low initial cost, simplicity and compactness so they will have a continued market and will be important factors for the next ten years. They will, however, have seven main bearings, he said. V-6's and flat sixes have costs approaching that of V-8's, and have no particular virtues unless they are required for unconventional chassis, he pointed out.

L-heads can't provide breathing at high compression ratio and are being out-distanced by available fuel, so they are on the way out. Sometimes the F-head breathing advantage is hurt by the use of expedient tooling for production, he asserted. The F-head will be used despite casting difficulties, and the bulk of the engines will have overhead valves. Push-rod actuated valves impose a limit on engine rpm because of vibration and mechanical limitations. There is a real possibility in the use of overhead cams, despite three peculiar problems of noise, cost, and valve lash control.

Larger bores provide room for bigger valves, bearings and cranks, Raviolo pointed out. The present bore/stroke ratio, ranging between 0.8 and 1.25, might be as high as 2:1 in other engine configurations, with resulting increases in efficiency.

Multiple Carburetion

Multiple carburetion will continue, probably with improvements in the form of separate throttle control of each venturi. The present four-barrel types provide for maximum horsepower output, but the feeding of pairs of cylinders from single venturis can be a help in improving torque. When the present enthusiasm for horsepower has run its course there may be a combination of the two techniques, with emphasis on improving torque. Because the four-barrel carburetor has been costly, and because the cost of fuel injection is gradually being reduced, it may be that fuel injection has better future prospects.

As to supercharging—this is the costliest way of getting performance. It is possible to build a good engine at less cost than the cost of a supercharger with its expensive bearings and gear.

Diesel engine virtues are tied to the lost cost of fuel, but taxes are altering this picture. Long-life attributes of the diesel engine are in part due to the ratings given the engines, Raviolo declared. He touched on LPG as a fuel and commented briefly on its clean burning characteristic. This feature extends engine life several times over that experienced with present fuels. If gasoline could burn as clean as LPG, Raviolo hinted that we might have an avenue to longer life between

overhaul, but he didn't suggest how it might be accomplished.

Gas Turbines Coming

Gas turbines are coming; that is a foregone conclusion, according to Raviolo. The problems of high speeds and high temperatures are reaching solutions through the pioneering of aircraft companies and through the research that at least several of the automobile companies have undertaken. His guess is, however, that it will take more than 15 years for the adaptation of these powerplants to passenger car use.

The speaker refused to comment on atomic power for vehicles because the problem is not yet defined and government exclusion of industry precludes any definite knowledge of the subject at this time.

He summarized and predicted on this basis: there are four main areas of future work on powerplants—(a) durability, (b) noise and vibration, (c) power and economy, (d) fabrication and cost. The latter is the most promising for future developments. High strength irons, with a modulus running up to 24-27 million pounds, provide one of the avenues, he suggested. Powdered metals which can make parts as complex as die castings and as strong as machined materials, suggest the possibility of economic production of such intricate units as injector bodies, he said. Plastics can be used on engines for cover plates and so forth. Aluminum, which is coming down in price and increasing in availability, may be more useful; he pointed to the recently-demonstrated technique of permanent molding sections, which are then brazed together to form engine blocks.

Weight Reduction

Foundry techniques, which still provide one-quarter inch wall thickness when only one-sixteenth inch is needed, offer one of the greatest opportunities for improvement. Reduction of casting weight through such means helps to get closer to the goal of more cubic inches (of engine displacement) per pound and per dollar. Raviolo looked favorably on the prospects of using stamped welded or brazed parts for engines (like Crosley) but warned against overenthusiasm. Fresh outlooks are needed, not just attempts to reproduce castings and forgings with stamped parts that look like the castings and forgings.

An analytical approach to these problems will pay big dividends, he concluded.

Toastmaster for the evening was Howard B. Speyer, vice-president and assistant treasurer of the Champion Spark Plug Co. The meeting plans were made by H. H. Vogel, director of engineering for Champion, and J. J. Nopper, AP Parts Corp., who are regional vice-chairmen for the Detroit Section.

Urges Participation In Highway Legislation

• New England Section

John W. Jacobsen, Field Editor

May 5—**Emil P. Gohn** spoke on important factors affecting highway transportation, particularly as they apply to commercial vehicle operation. Gohn, automotive engineer for the Atlantic Refining Co., was sponsored by J. Roy Smith of the Metropolitan Transit Authority, activity chairman of Transportation and Maintenance.

The speaker discussed legislative trends which will affect automotive fleet operation, mainly those of a technical nature, over which the fleet owners and operators can exercise control. Regarding the proper selection of equipment, Gohn recommended consulting SAE special publication SP-82, "Truck Ability Prediction Procedure," which will enable the operator and the manufacturer to reach compara-

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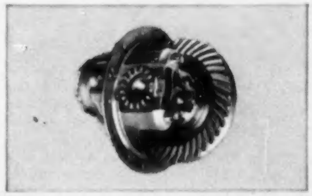
gear each truck to its specific job!



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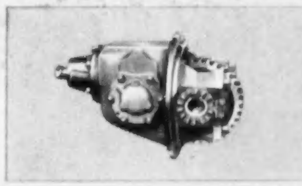

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ble conclusions as to the exact specifications for a particular type of operation.

Commenting on the legislative aspects of the fleet operator's problems, Gohn stated that the most striking factor in highway transportation is its phenomenal growth. Of the 120 million vehicles produced since 1900, more than 52 million are now registered in active use.

One out of every four legislative bills introduced in States affects highway transportation, Gohn said. If the fleet operator does not make it his business to become active in legislative developments, then he must be content to let this business be handled by others less capable than himself.

Regarding preventive legislation, Gohn commented on those laws concerning truck noises and use of mudflaps. Cooperation between the truck owner, operator and manufacturer will do much to offset restrictive legislation of this type. The most troubling aspect of the above mentioned laws is the complete lack of uniformity between the several states having such statutes in effect at the present time.

In conclusion, Gohn said that truck fleet owners have benefited from technical advances by working closely with vehicle manufacturers — comparable benefits can be obtained by working closely with lawmakers regarding preventive legislation.

During the meeting, Chairman Harry Stanton introduced William F. Mahan, Bendix-Westinghouse Corp., who read the slate of officers elected for next season. They are: Chairman—Reginald H. Robinson, Gulf Oil Corp.; Vice-Chairman—Gustav Heiber, Boston & Worcester Bus Lines; Secretary—Lewis W. Kerr, Franklin Technical Institute; and Treasurer—Charles M. Fluke, White Motor Co.

Discusses Drawbacks To Jet Transport Use

• Chicago Section

L. C. Kidd

April 14—A large, enthusiastic, and inquisitive group attended the aircraft meeting of the SAE Chicago Section. There were nearly 300 members and guests in attendance, including a few representatives from foreign countries. The dinner was preceded by a social period sponsored by the Bendix Products Division.

Technical chairman was Arthur J. Volz, vice-chairman of aircraft activity and also chief design engineer, fuel metering systems, Bendix Products Division. **F. W. Kolk** of American Airlines was the speaker of the evening. Kolk presented a slide-illustrated talk on the subject of "The Gas Turbine as a Commercial Power Plant."

Kolk explained that the successful postwar application of gas turbines in England to the propulsion of commercial aircraft had posed a serious challenge to the American air transport industry. Apparently the Britishers have seized upon jet power as a means of gaining a competitive advantage over their American cousins. Then, too, jet-type aircraft engines were originally the product of British inventive genius, so that England is working from an initial lead.

Several prototype airplanes for passenger transportation have been developed in England. The British "Comet" is the foremost airplane of those that have been developed, and has been the one most extensively used in commercial airline service. This plane cruises at 460 miles per hour at altitudes ranging from 32,000 to 42,000 feet. It is powered by four deHavilland Ghost turbo-jet engines,

each developing 5,000 pounds thrust. The primary disability of the Comet is that, like other craft powered by turbo-jet engines, its fuel consumption is so high that frequent stops for refueling are necessary.

Kolk discussed the relative merits of turbo-jet and turbo-prop engines. He pointed out that there is less noise and that less take-off distance is required with the turbo-prop than with the turbo-jet form of propulsion. While thrust output can be increased, with a resultant decrease in the required take-off distance, by the installation of after-burners on jet engines, this expedient is undesirable because it aggravates the already objectionable level of noise associated with the operation of engines of this type.

It was Kolk's conviction that gas turbines would not be applied commercially to transport aircraft in this country for several more years, probably 1958 at the earliest. He mentioned, to illustrate his point, that American Airlines has placed orders for several new Douglas DC-7 airplanes powered with Wright cyclone R-3350 piston engines, and that these new models will not be placed in airline service until 1954. A minimum of five years of operation of new airplanes is considered necessary in order adequately to amortize the initial investment.

Because of the high initial cost of gas turbines, considerably above that of the reciprocating piston engines they would replace, Kolk believes certain prerequisites must be met in order to justify their application to commercial airplanes. To compensate for their high first cost, gas turbines should have a greater life expectancy than piston engines, should operate for longer periods between overhauls, and should require the replacement of less parts at time of overhaul.

Kolk emphasized that, from the safety standpoint, the transition from reciprocating engines to gas turbines must be a forward step, not a backward step. The long take-off distances required by certain jet-powered transport airplanes is considered a safety handicap. Rocket-assisted take-offs may be one solution to this problem, but he pointed out that this is expensive, inasmuch as the rockets used on large transport airplanes cost about $100.00 each.

Containment of fires that might develop in the nacelle that houses a gas turbine is another safety problem. It is essential that such fires be confined to the engine compartment and not be permitted to spread to the wings and other structural components of the airplane.

There was a lively session of comments and questions following Kolk's talk. The interest of the audience was indicated by the fact that nearly everyone remained in his place throughout this question-and-answer period that lasted for about three-quarters of an hour.

Social Evening Concludes Program

• Mohawk-Hudson Group

Knud Antonsen, Field Editor

May 8—"Ladies' Night" held by the Mohawk-Hudson Group at the Locomotive Club, Schenectady, marked the end of a successful season under the leadership of Chairman John J. Broderick. This was the second year the group devoted its last meeting to the ladies. The program included a short business meeting, at which officers for the coming year were announced.

Two films by the Shell Oil Company were shown, one of the 1950 Silverstone Race in England, the other of the 1952 LeMans 24 hour race in France.

Music for dancing was provided by Don DeCarlo's orchestra, and during intermission the "Clippers" entertained with barbershop quartet singing.

Local company representatives donated many pieces of valuable merchandise to be given away as door-prizes. Towards the end of the even-

ing a buffet supper was served.

John J. Broderick, chairman of the Mohawk-Hudson Group for the 1952-53 season, was presented with the traditional "past chairman's certificate" by Ralph J. Hooker, vice-chairman.

Gives Data On GM Air Conditioner

• Metropolitan Section

S. G. Tilden, Jr., Field Editor

May 7—"Public interest indicates a demand for air conditioning in automobiles", stated **D. C. McCoy** of Frigidaire Division, General Motors Corp. "The market now seems to justify production of a factory-built system," he told Met Section members.

Outlining the eight basic elements of air conditioning systems, McCoy in his paper titled "Your Car Can Beat The Heat" explained the overall problem in applying these elements to an automobile. This, he explained, requires compromises in the component parts of the system, both in their design and application, to cool the automobile without affecting the utility or performance of the car itself.

In outlining the required performance of the air conditioning system, McCoy referred to "the summer 'comfort zone' representing satisfaction for a majority of people." This is a condition of 78 F dry bulb, 50% relative humidity, with an air velocity over the body of 25 feet per minute.

To show by comparison the task at hand, McCoy charted the ratio of space to be cooled to the required air delivery for three air conditioning installations as follows:

1 hp Window Unit (for home):	11.3
Railroad Coach Car:	2.1
Automobile:	.53

The basic problems having been stated, McCoy demonstrated, with the aid of slides, Frigidaire Division solutions to them. The compressor, a Frigidaire "Meter-Miser," a rotary-type, is mounted under the hood above the engine and is driven by a double V belt.

The refrigerant, Freon #12, is circulated from there to the condenser, located ahead of the radiator, to the refrigerant receiver under the splash pan in the front of the car. Circulation proceeds from this point under the passenger compartment through a metering valve, a dehydrator, a filter, to the evaporator located under the package shelf in the trunk compartment. Here it accomplishes a heat transfer with the circulated air and is returned again to the compressor.

The air in the passenger compartment is circulated by means of two 6 or 12 volt blowers also mounted in the trunk, with some 25% outside air introduced by means of pick-up grilles on the rear fenders.

Speaking of performance, McCoy


They're pouring futures in the foundry!
When man first cast molten metal, he poured himself a future. He started something that has become more and more important – a process our great industries could not do without. The results are everywhere. You'll find castings used again and again in a multitude of applications. They're on the horizon, too . . . clearly marked for the products of tomorrow.
Helping push this progress in the foundry is Campbell, Wyant and Cannon. From the cupolas, electric furnaces, and converters of CWC flow metals with a background based on new ideas, new processes, new methods in casting techniques. Not content with producing the best of today's castings, the engineers of CWC are already planning the things to come. Remember, for all that's new in castings, keep your eye on Campbell, Wyant and Cannon.
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said, "Based on tests to date, on a 100 F day it is possible to produce comfortable conditions in approximately six city blocks of driving, with suitable driving conditions."

In the question period that followed the paper McCoy revealed that the installation uses from 2 to 9 horsepower, and that thus far there have been no adverse effects on engine cooling by placing the condenser ahead of the radiator. Maintenance on this system, he assured, was a bare minimum; in fact he said that as with any air conditioning system, it is far better if left alone.

Says Color No Index Of Lubricant Cleanliness

• Northern California Section

J. A. Miller, Field Editor

March 25—**H. M. Gadebusch** of GMC's Detroit Diesel Engine Division discussed, "Clear Crankcase Oil Color or Clean Engines?"

Gadebusch outlined how sludge and varnish deposits are formed in an internal combustion engine and how crankcase lubricants containing chemical additives combat this deposit formation and reduce engine wear. The discussion emphasized the fact that the old criterion for oil drain, dark oil, is no longer applicable to these modern oils and that a sludged oil filter now indicates need for oil drain.

As a rule of thumb, Gadebusch stated that if sludged filter elements are found in an engine at normal oil change with a detergent oil, then the drain period must be reduced or an oil of the next higher detergency level employed. It was also emphasized that, to take full advantage of the superior qualities of highly detergent motor oils, operators accustomed to color-clean oils and sludged filter elements must learn that sludge-free filter elements and black oil color are characteristic signs of proper performance of heavy duty lubricants and do not reflect on the quality of the oil or efficiency of filtration.

Guided Missiles Force New Defense Concept

• St. Louis Section

E. E. Wallace, Field Editor

April 14—"Guided Missiles and the Weapon System Concept" was the subject of a paper presented by **Arthur L. Lowell**, head aerodynamicist of the Missile Section of McDonnell Aircraft Corp.

Lowell pointed out that the rapid advances in weapon technologies have greatly complicated the hitherto relatively simple tactical and strategic

military planning, and have resulted in the rise of the "weapon system concept."

The immense destructive powers of the new weapons and the rapidity with which they can be used on a global scale means that defenses against them must be capable of detecting an attack at long range, analyzing it as to strength, speed, probable targets, and so forth, alerting the defensive groups and deploying them so as to resist the attack most effectively.

It becomes apparent that an over-all defense philosophy is required; that types, quantities and disposition of defensive weapons must be controlled; and that a high degree of co-ordination and flexibility must be maintained. All of this must be provided at an expenditure within our economic and manpower limitations. Warfare then depends on a "weapons system" rather than a variety of only generally related weapons and means of offense or defense.

Guided missiles play an important role in any such system, said Lowell, because of their ability to deal retaliating or defensive blows with great rapidity and accuracy.

Lowell briefly enumerated the four basic types of missiles: surface-to-surface, air-to-air, surface-to-air, and air-to-surface. Dependent on their use, missiles may have any one of three means of propulsion. The slow speed types (about Mach 1) may employ turbojets. Ramjets are well adapted to intermediate speed types, and the extreme speed or extreme altitude missiles are best handled by rocket propulsion.

Following Lowell's talk, movies were shown. One, "High Altitude Research," made by the Johns Hopkins Applied Research Laboratory, covered firings of German V-2 and Navy Aerobee rockets. The other consisted of captured German films of V-2 rocket firings.

Prospects Poor For Atomic Autos

• Cleveland Section

April 13—A most interesting discussion of a highly technical subject was given by **Dr. L. R. Hafstad,** director of reactor development, Atomic Energy Commission, at the Akron-Canton Meeting. "Progress Report on Atomic Power" was the subject of his paper.

The meeting was attended by members from all over northeastern Ohio and was capably presided over by vice-chairman of the Akron-Canton District R. H. Spelman, General Tire & Rubber Co. Dan Kimball, vice-president of General Tire and former Secretary of the Navy, presented the speaker.

Dr. Hafstad explained the process by which neutrons penetrate uranium and collide with atoms of that material to start a chain reaction of fis-

sions. In handling atomic power, he also explained the problem connected with materials, such as neutron absorption, resistance to radiation, and high temperatures. It is unlikely, he said, that we will use atomic energy in the automotive field for some time to come due to the shielding problem.

There are high hopes for long-term industrial use where fuel consumption has been a problem. Good progress has already been made in submarines due to compactness of the powerplants and the unlimited cruising range. Industrial investigations are going forward, and much may be expected in this field, although it takes time.

The Akron-Canton Committee in charge of the meeting was composed of W. H. Elliot of Goodrich, Wade C. Johnson of Goodyear, L. W. Fox of Firestone, E. H. Gibbs of Seiberling, L. K. Acheson of Hoover Co., A. P. Thomas of Timken, and J. F. Male of Hercules.

Television Show

The second SAE television broadcast on the series, "Adventures in Engineering," was offered on Sunday, March 22, with professional-like results. Ted Thoren, Ed Bisson and Robert Cass showed real stage talent in their acting roles, and the two student members of the cast—Rose Schmidt of James Ford Rhodes High School and R. C. Steeneck (son of Bob Steeneck) of Cleveland Heights High School—gave a superb performance. John Stirling, who was chairman, has been elected permanent TV Chairman of the Cleveland Section in charge of other SAE programs to be presented in the future.

Safety Topic Of Two Papers

• Chicago Section

E. A. Comfield

March 10—A double-barrelled program was presented to Chicago Section members in a combined meeting of the Truck & Bus with the Transportation & Maintenance Activity. Chairmen Don Wing and Arthur C. Schmidt introduced the speakers who presented very timely papers on the subject of safety.

E. T. Christian, supervisor of Retail Motor Truck Service for International Harvester Co., discussed "The Manufacturer's Angle On Safety," a dissertation on the many important items involved in truck and bus design in which safety is a prime consideration.

In view of the fact that trucks alone compose 17% of the traffic on our highways, they represent an important element in problems of safety. Among the items receiving special attention by manufacturers are the problems relating to driver comfort to prevent fatigue, improved visibility,

instrument location, brake systems and power steering. **Safety tanks** of approved underwriter's design are in increasing demand by operators of highway vehicles.

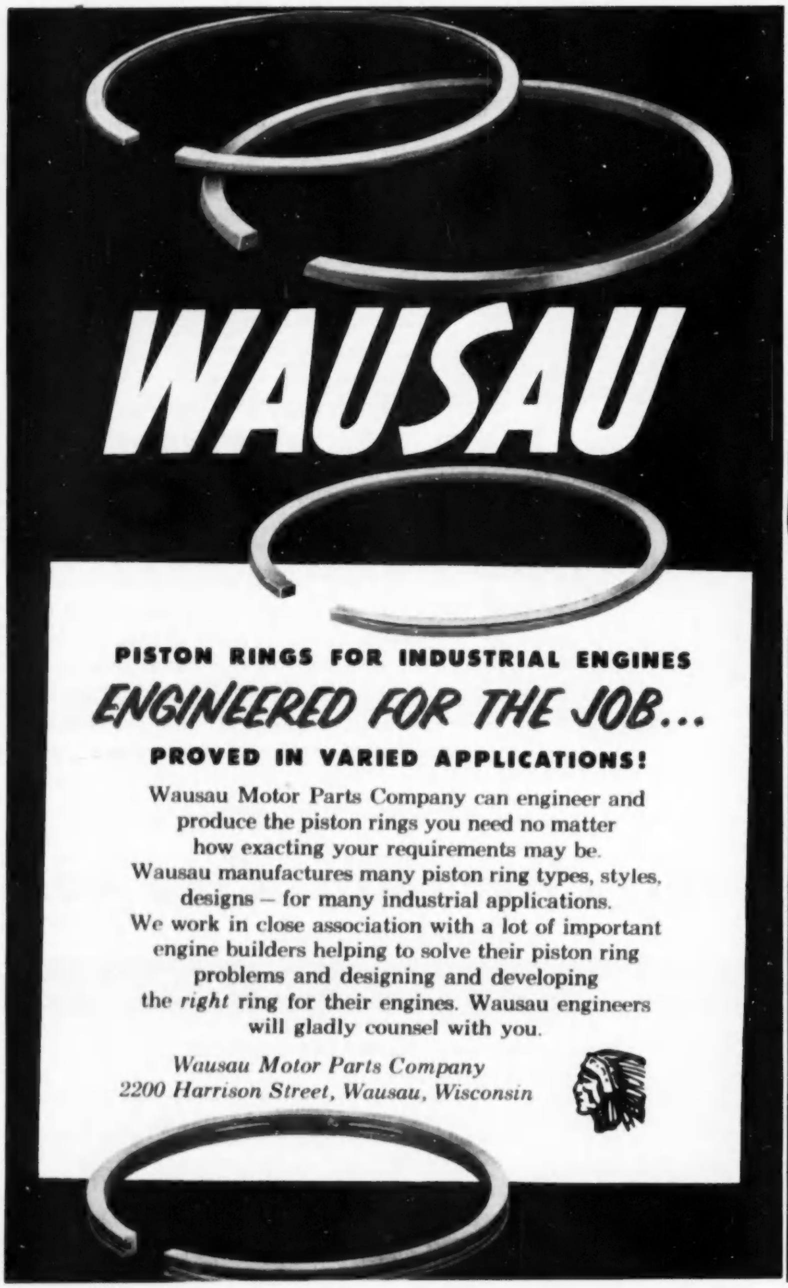
Improved tire design and developments in synthetics have contributed much to increasing life as well as safety in high speed heavy duty operation.

Christian emphasized the importance from the safety angle of purchasing truck equipment adequate for the loads, speeds and operating conditions to be met, as well as having trained operating personnel who are constantly aware of the importance of careful observance of all rules of safe operation.

E. J. Emond, director of automotive safety for Armour and Co. supplemented his paper with the engaging title "We're Not Kidding About Your Skidding" with a motion picture of the Winter Driving Tests made near Clintonville, Wis., by the National Safety Council's Committee on Winter Driving Hazards.

This picture disclosed some of the tests made on various types of ice and snow encountered in winter driving. Tractors and semi-trailers were deliberately caused to skid and jackknife by various types of braking; the results have been evaluated in a booklet published by the National Safety Council entitled "Basic Winter Driving Rules On Techniques, Equipment and Safe Practices."

These driving tests are conducted each winter and automotive concerns are urged to cooperate and participate in this program.



New Techniques Used In Guided Missile Research

• Chicago Section
D. J. Schrum

March 16—The South Bend Division of the Chicago Section closed its 1952-53 season at a dinner meeting attended by 140 members and guests and featuring a paper on "The Impact of Guided Missiles on Modern Engineering" by **John A. Parchem** of Bendix Products Division.

During and since World War II, the nature of difficult problems like the Manhattan Project and the development of guided missiles has given impetus to an engineering approach never fully exploited before. This approach has to do with methods for solving problems and devices for implementing designs and the final product. Early developments of control and propulsion systems during the war brought a knowledge of high speed aerodynamics and the basis for the development of a truly automatic guided missile.

Control systems for these missiles are based on a principle of closed loop feed back. Parchem illustrated this principle with the thermostatically controlled furnace, whereby a room temperature below thermostat setting will cause the thermostat to call on the furnace for heat. As the heat is generated the room temperature will cause the thermostat to call for less heat from the furnace. Thus a comparison is being made between the required condition and the existing condition and correction made on the basis of difference.

It can be seen from this analogy that a feedback control system on a missile will be actuated by error in performance, whether it be position, velocity or acceleration; the controls will constantly attempt to reduce the error to zero.

With this feed-back concept of control accepted, the problem of studying such controls under varying operating conditions would involve an unsurmountable volume of mathematical calculations. Whatever progress has been made in guided missiles to date

would not have been possible without the use of electronic computers which are playing an important part in the changing picture of engineering design.

The two types of machines in use are known as digital and analog computers. Potentially the digital can handle any scientific problem, but it must be done in terms of arithmetic operations.

By contrast, the analog attacks the problem by doing the required mathematical operations directly. Thus it is possible to set up the conditions imposed on the control systems and determine the reactions in the design stages. It was pointed out that in missile design there is no place for trial and error methods, and the designer must be right the first time.

In addition to Parchem's discussion, films were shown of the German V1 and V2 rockets, as well as some of the developments in the United States.

Outlines Problems Of Tire Improvement

• Washington Section

Allen P. Blade, Field Editor

A. P. Blade

April 21 — **Dr. Arthur W. Bull,** director of tire development, United States Rubber Co., discussed some of the major items of tire development before an attentive audience of members and guests.

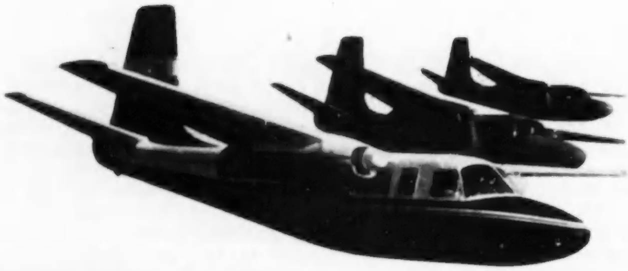
Usually the automotive engineer is willing to let the tire industry struggle with the problem of selecting the best materials and designs for tires, provided it continues to furnish tires which will deliver a steadily rising level of performance, said Dr. Bull. Some of the basic requirements are:

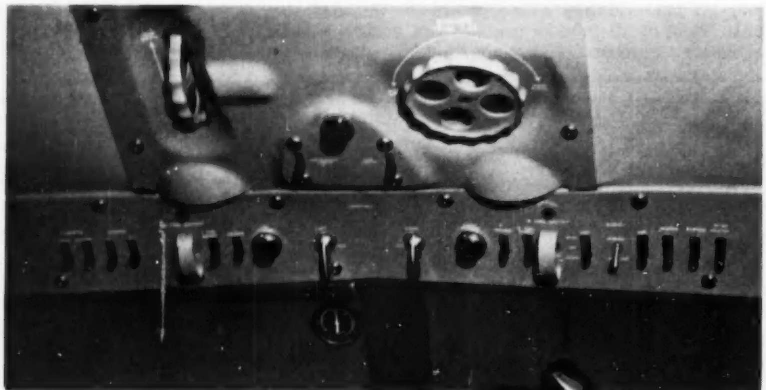
1. The tire must provide a continuous, self-damping cushion to minimize the transmission of road shocks to the vehicle.
2. It must provide a mobile but continuous road contact, of sufficient coefficient of friction to permit the application of large driving and braking torques and the maintenance of vehicle control.
3. It must perform these major functions with a minimum amount of trouble, low friction losses, light weight, minimum cost, and maximum endurance.

Although tires appear to be quite simple, the operation of such a flexible structure is highly complicated. Every detail of material in the tire, and every detail of the construction and design have been subjected to an increasingly critical scrutiny for many years. Because of this research work, principally in the laboratories of rubber companies, tire quality has been steadily improved and tire costs have gone down. This is in spite of the fact that cars have become heavier and more powerful, so that tires are required to do more work.

Before a new tire is accepted it must prove its performance in many directions. First of all, it must provide adequate tread mileage. How many miles should you expect to get from a set of tires? It is no easier to answer this question than to say how long a pair of shoes should last. Roads are known on which, by hard driving, you can wear out any set of tires in 1000 miles, and yet many drivers can get 50,000 miles from similar tires under their own operating conditions. The driving habits of the car operator are the most important factor in determining tire mileage. Climatic and geographic differences also play a part.

Data was shown from regular sur-





veys comparing tire mileages over a period of years. Tire sizes have been changed three times and there have been many changes in the cars with increases in weight and power. The net result has been a rather steadily increasing tire mileage—convincing evidence that the car owner is receiving better and better performance.

There has been a major change in the relative wear on front and rear wheels. Before the days of front wheel brakes and independently sprung front wheels, rear tires used to wear out twice as fast as front tires. Today front tires usually wear at a faster rate than rear tires. The fact that front tires now usually carry more than half the load is an important factor in this change. Tire wear, like most tire failures, is sensitive to load.

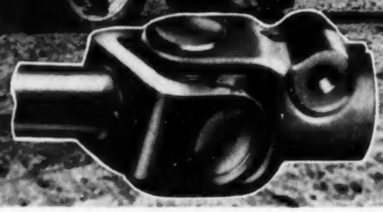
Tests show that the rate of wear is more than proportional to the load. Tires which are overloaded 10%, for example, may deliver 30% less tread mileage than tires run at the standard loads shown in Tire and Rim Association tables.

Dr. Bull then discussed the mechanism of tread wear. It is axiomatic that rubber is abraded only because of movements of the tread in contact with a road surface under pressure. Sometimes you can have excessive movement under pressure without appreciable loss of tread, for example when tires are spinning in snow or on smooth ice. Under other circumstances, such as a locked brake in an emergency stop on a dry road, you have very rapid loss of rubber because the friction between the road surface and the tire is so high that the surface layer of the tread quickly reaches the burning point. It is suspected that even in normal driving a considerable part of the tread loss results from oxidation of the rubber.

The relative tread movement between a tire and the road surface is influenced by many factors, perhaps the most important being the driving and braking torques, which are large in magnitude. In addition to these torques, the front tires are subjected to an additional circumferential torque equivalent to the rolling resistance of the tire. This has the same practical effect as a continuous mild brake application. In addition to these circumferential tread movements due to torque, there are complicated lateral and circumferential tread movements of the tread elements which result from the change in shape of the tire where it passes through the road contact area. These movements also contribute to tread abrasion and particularly to the development of irregular types of wear. Finally, there are frequent, powerful, lateral tread movements induced by cornering forces on the vehicle. Skidding on turns would represent extreme movements of this kind, but minor lateral movements occur even in mild cornering when side skid is not obvious.

The rate of abrasion rises rapidly as the torque is increased with result-


FOR LARGEST TRACTORS

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ing increase in slip or tread movement. Tires running without any circumferential torque deliver phenomenal mileage. At normal tire load and inflation and zero torque, it takes more than 200,000 miles to wear off the tread design. As circumferential torque is increased, the rate of abrasion of the tread increases rapidly. If a driving torque equivalent to 10 hp at 30 mph is continuously applied to the tire, the tread design will be worn smooth in about 10,000 miles.

Skid resistance has been the subject of very extensive study. Road materials are diverse and nature complicates the problem by adding ice, snow, sleet, mud or rain.

Stability

Another problem of great importance to the automotive engineer is the question of car stability which depends on complex behavior of the tire. Slides were shown to illustrate use of a dynamometer and other special equipment to measure the side thrust and also the self-aligning torque developed by any tire over a range in steering angles with different inflation pressures, speeds or rim widths.

A phase of tire performance which has had a good deal of attention is the question of tire noise. Practically all broken tread designs produce noise when the design elements meet or leave the road surface. By using nonuniform lengths of the design elements the sound has been made much less objectionable. Unfortunately a tire is an effective resonant diaphragm and when any part of it is set in vibration, sound waves travel around and through the tire.

Another type of tire noise which has been quite annoying is the noise on turns. This has been especially prominent in the extra low pressure tires. Progress has been made in modifying the volume and character of this squeal, although it is not sure that its complete elimination is desirable.

Another type of noise which has become quite troublesome is usually referred to as "thump." It is a vibration definitely excited by the tires, manifested inside the car by low frequency vibration of various resonant surfaces. Since an excessive flat spot on a tire can produce a noise similar to true thump it might be expected that thump would be directly related to an out-of-round condition or to an unbalanced condition or perhaps to a combination of both. Neither of these measurements correlate with thump rating. However, there is correlation between thumping and what is called deflection uniformity. Tire uniformity is being improved by constant efforts and the use of more precise equipment, but there are practical limits beyond which you cannot expect further improvements except at prohibitive cost.

Dr. Bull's talk, illustrated by many slides, thus covered some of the more important problems of interest to both tire and automotive engineers. As he pointed out, some of the problems can be solved only by cooperative effort.

Douglas Bonn was technical chairman of the very interesting meeting.

New Members Qualified

These applicants qualified for admission to the Society between April 10, 1953 and May 10, 1953. Grades of membership are: (M) Member; (A) Associate; (J) Junior; (SM) Service Member; (FM) Foreign Member.

Atlanta Group

David G. Murrell (A).

British Columbia Section

Ivan John Carr (J).

Buffalo Section

Phillip B. Eyre (J).

Canadian Section

Ernst Willy Portmann (M), Bernard Seignuer (M), George Adolphe Sherl (M), J. B. Webster (A).

Central Illinois Section

Thomas W. Head (J), Vergil Phillip Hendrickson (J), Milton B. Holland (M), William Lloyd Holmstrom (J), Ernest W. Landen (M), George T. Lundberg (M), D. C. McCann (M), James E. McDowell (A), James W. Schoonover (M), Donald W. Smith (M).

Chicago Section

William Edson Bachman (J), Don L. Clithero (M), Frank A. Glomb (M), Louis M. Gray, Sr. (M), George Willard Hambrook, Jr. (M), Joseph A. Hopkins, Jr. (A), Frank Carl Janda (J), John E. Smart (M), Ernst Wilhelm Spannhake (M), John E. Starr (M).

Cincinnati Section

Louis W. Adams (A), J. S. Parker (M), E. V. Sharpnack, Sr. (M), Edward H. Stivender (M), Marvin Wernersbach (A).

Cleveland Section

Robert C. Dyrenforth, Jr. (M), Clifford A. Fordham (M), Melvin Joseph Nicoulin, Jr. (J), Victor Rovtar (M), Frederick T. Schuller (J), John R. Sutton (A).

Dayton Section

Daniel E. Krause (M).

Detroit Section

Donald J. Armstrong (A), Pedro Lorenzo Delgado (M), Richard C. Devereaux (A), Darius D. Dustman (A), Arthur Edwin Franzen (J), Lester M. Goeman (M), Richard William Heater (M), Richard Edward Heruth (J), Charles E. James (A), J. Jerome

Continued on Page 130

New Members Qualified

Continued

Jordan (A), Malcolm R. McKinnon (A), Steve J. Nagy (A), James J. Nance (M), Loren R. Papengurth (J), John F. Pierce (A), Robert P. Reilly (J), Louis Joseph Rice (M), Victor A. Rusnack (M), John J. Schickel (J), August J. Scussel (J), Ronald Joseph Semak (J), Arnold H. Stenzel (J), Jerome D. Vanek (A), Eugene A. Wingerson (M), Parke Woodworth (A), Nicholas J. Wyles (A), Leonard O. Zick (A).

Hawaii Section

Francis E. Burns (A).

Indiana Section

William James Nanfeldt (M).

Kansas City Section

Earl R. Allgeyer (J), B. G. Hockaday (M).

Metropolitan Section

Henri N. Bacon (A), Donald Robert Duncan (J), Wallace I. Goddard (J), Joseph P. Hamer (M), Henry M. T. Harris (M), Robert S. Norris (M), Herbert M. Perkins (J), Naseem Ahmad Siddiqui (J), Robert M. Silverman (J), Edward N. Townsend, Jr. (M), Carll F. Van Gilder (M).

Mid-Michigan Section

Albert W. Foster (J), Paul H. Kehm (J), Dale H. Winfield (J).

Milwaukee Section

Wilbur L. Dykhuizen (J), Harold G. Holler (M), F. S. Kubiak (M), Swaraj Vrat Panjratan (J).

Mohawk-Hudson Group

Raymond T. Lewis (M), Curtis Garwood Talbot (M).

Montreal Section

Arthur Roger Dupuis (M), Thomas George Hunter (A), Jack E. Reichelt (A).

New England Section

John F. Flanagan (M).

Northern California Section

Detrick Cooter (J), Vernon Theodore Nelson (J).

Northwest Section

Gerald Michael Lefoley (J).

Philadelphia Section

Robert B. Brown (A), F. Edgar

Continued on Page 133

What Salisbury engineers said to Mr. Spicer

When the Spicer people bought the Salisbury Axle Company in 1919, the advantages of Salisbury Axles had been widely used in automobiles and trucks since 1906.

As the Salisbury engineers pointed out to Mr. Spicer, and our young president, C. A. Dana, when the purchase was being considered, "This axle has distinctive features you can't find in any other unit. We've just had several years of front- and rear-drive war service — the kind that no axles have ever had before. Our design is *good.* That will be proved by its increasing acceptance through the years ahead."

During the past 34 years, Spicer has made millions and millions of Salisbury Axles for a wide range of civilian and military uses.

Designing, Developing, Engineering, Spicer Manufacturing and Service

New Members Qualified

Continued

Pelly (M), Thomas L. Scatchard (A), Gregory Joseph Siragusa (J), James O. Yule (J).

Pittsburgh Section

Preston E. Berry (A), Fred W. Fest, Jr. (J), A. J. Parsons (M).

St. Louis Section

Joseph M. Levon (J), Thomas D. Spragle (J).

San Diego Section

Thomas H. Chadwick (M), Bernard Gross (M), George Scott Oliver (M).

Southern California Section

Daniel B. Coleman (M), Robert M. Cox (J), Arthur J. Iler (A), Robert J. Sandke (A).

Southern New England Section

George F. Anger (A), John H. Johnson (J).

Spokane Intermountain Section

Benard Wilfred St. Clair (J).

Texas Section

Richard Edward Allen (J), William Preston Goode (J), Paul R. McMahan (A), Horace E. Vail (J).

Twin City Section

Clayton Kenneth Tuckwell (M).

Virginia Section

Joseph W. Howell (J).

Washington Section

Louis Booth Feldman (M), Lt. Col. Franco E. Fiorio (M), Lt. Arnold J. Tenner (J).

Wichita Section

Clay W. Lewis, Jr. (M).

Williamsport Group

Albrecht W. Hussmann (M).

Outside Section Territory

James Colburn Addison (J), Nathaniel T. Bartholomaei (M), Capt. Laurence Arthur Beilby (A), D. E. Crooker (A), Seymour J. Feinberg (J), David K. Nason (J), Anthony Orsini

Continued on Page 134

New Members Qualified

Continued

(M), Henry John Rymes (A), William E. Stoffregen (A).

Foreign

Stanley Brownlie Duncan (M), England; Francis John Eames (M), France; Lt. Col. Robert Kenneth Gregory (M), England; Brinley Jones (M), England; Cesare Tonegutti (M), Italy; John Granville Withers (M), England.

Applications Received

The applications for membership received between April 10, 1953 and May 10, 1953 are listed below.

Atlanta Group

Tommy Eugene Adams.

Baltimore Section

Nicholas V. Petrou, John K. Stull.

British Columbia Section

Donald James MacKenzie, Norman McCaskell, Harold G. Rand.

Buffalo Section

Robert N. Cruser, Milton B. Punnett.

Canadian Section

John K. Abel, Maciej Achmatowicz, John Edward Carney, D. Clifford King, Leslie J. LaDouceur, Thomas E. McLeod, Charles Franklin Stevenson, Harry Wogden, Leslie Thomas Woodhouse, Charles Douglas Wright.

Central Illinois Section

Henry Dean Bordeaux, Robb P. Brem, Oscar M. Harding, Jr., Raymond A. Jump, Paul A. Mitchell, Howard R. Moos, Loren Derol Munro, Lester Lee Pierce, W. P. Sebree.

Chicago Section

Roger B. Baird, Harry H. Bostrom, Robert William Bowers, John R. Branstrator, Robert Keith Brown, Howard Eugene Chana, Harry J. Dagley, T. C. Delker, Melvin M. Hann, Alfred C. Kengott, Edmund J. Kujawa, Willis O. Pulver, Elling H. Runden, Jr., Steve F. Sipovic, Edward A. Wheelock.

Cincinnati Section

James F. Cox, Martin C. Hemsworth, Harry A. McFarland.

Cleveland Section

David B. Albrecht, George E. Armington, William Bergner, John L. Bigelow, John C. Cobourn, Jack W. Dunbar, Henry Friedrich, Thorgrim E. K. Kjolner, William J. Kundrat, Harlan C. Paige, Paul L. Reed, Borje

Continued on Page 136


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ECHLIN MANUFACTURING COMPANY · DEPT. SAJ, 200 EAST STREET, NEW HAVEN 5, CONN.

Applications Received

Continued

Rosaen, Philip Walter Skove, Nelson G. Spoth, John Ivar Wahlstrom.

Colorado Group

Robert L. Caughey, Charles Beverly Gunn.

Dayton Section

S. H. Hanville, Jr., Ernest A. Weil.

Detroit Section

Robert H. Appleman, Rupert B. Bell, Bruce G. Booth, John D. Caplan, Ray C. Conner, Rodney C. Dickinson, Tammo G. Drewes, Frank C. Druzynski, Richard I. Emori, Donald L. Endicott, Martin J. Galli, Louis LeRoy Grant, Victor J. Harris, Harold Jennings Harvey, Elmer A. Herider, Danforth Holley, George N. Jenkins, Henry E. Kasner, Marden M. Kingman, Ralph E. Koldhoff, William Robert Konopacke, William H. Kahn, William A. Lerg, George P. Mathews, Godwin Udegbunen Meniru, Ronald R. Moalli, Robert Charles Nelson, George William Niepoth, Munamarty V. S. Raidu, Harold L. Sharp, William Reid Smith, Charles E. Sprigg, Howard E. Strong, Howard Clayton Sullivan, John C. Thrasher, Chester F. Wells.

Hawaii Section

Sam Harris, George W. Luter, Charles W. Read, Carl C. Sanders.

Indiana Section

Robert P. Loveland, Frank Essa Nasser, Carl L. Nigh.

Kansas City Section

Truman Hall.

Metropolitan Section

J. E. Ashman, Richard Clark Baubles, Elmer T. Davidson, William DeMayo, J. Nelson Frey, Charles F. Gotschalk, Jr., Donald E. Hasbrouck, Charles J. Knight, Arun Prasad, Samuel Ray, Robert Vann Richards, Ladislaw Edward Trefny, Marcus F. Warmuth, Elwood R. Zeek.

Mid-Michigan Section

Henry Thomas Daunt, M. L. Gilbert, Carroll K. Lenning, Edward E. Malloy, Henry J. Presser.

Milwaukee Section

Richard R. Bridge, John Frederick Jorgensen, James H. Lahey, Robert J. Rink, Keith H. Rhodes, Earl A. Ustruck, Raymond T. Wheeler.

Mohawk-Hudson Group

William C. Kraft, Harry Rose.

Montreal Section

Ronald J. Baker, Louis Philippe Lapointe, Bernard Lortie, Thomas Joseph Stringer.

Continued on Page 138

Applications Received

Continued

New England Section

Robert M. Gill, Irving Kalikow, A. F. Wiegand.

Northern California Section

E. I. Brajenovich, Morris E. Cain, Donald R. Fylling, Paul W. Morgan, Joseph M. Noble, Phillip Elton Weil.

Philadelphia Section

W. Herman Barcus, Frederick E. Seidel, Jr.

Pittsburgh Section

Walther L. Havekotte, Ross M. Stewart.

Salt Lake Group

Olonzo Adair.

San Diego Section

Richard W. Davis.

Southern California Section

E. Maurice Baruch, Lt. Robert A. Curtis, Clifton L. Englis, Philip E. Holzman, William H. Jahns, Jr., John Kairys, Nelson A. May, L. K. Rimer, John Keith Zaiser.

Southern New England Section

Philip E. Ashton, Robert Baer, John Chamberlain.

Texas Section

Robert F. Mountz.

Twin City Section

Richard Louis Baumgardner, Alfreds Mucenieks.

Virginia Section

Ivan H. Cox, Robert Clinton Seavers, Jr.

Washington Section

Robert J. Auburn, William C. Badders, Francis W. Maddox, John J. Murphy, N. Stanley Oates, Lt.-Col. Julio Salvador.

Western Michigan Section

Joseph F. Keusch, Jr., Donald Bryan Sewell, L. A. Zahorsky.

Outside Section Territory

Robert W. Fernstrum, Norman F. Hosford, Charles Allan Milton, Lt. (j.g.) Gerald David Olson, Robert R. Olson, J. W. Powell, Davis Merlin Schmitt, George Douglas Simonds, Jr., Teddy Russell Stauffer.

Foreign

Gordon F. May, England; Mohamed Sharker Mohideen, Ceylon; Ing. Prof. Angelo Patrassi, Italy; Heinz O. Voigt, Saudi Arabia.

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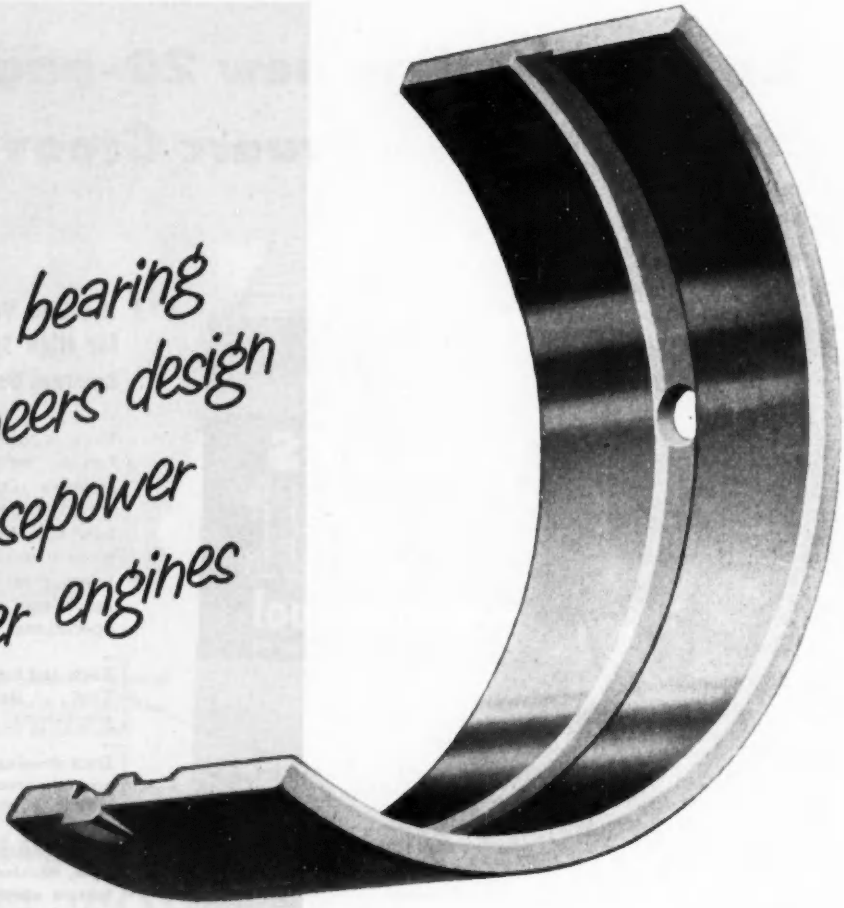
How this bearing helps engineers design more horsepower into smaller engines



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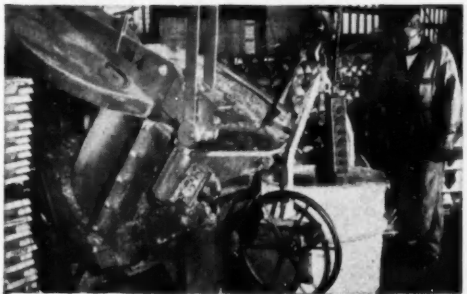
Raw material storage room where ingots are held for laboratory analysis. Temperature is controlled to prevent moisture pick-up.



Electrically operated melting furnace in the Thompson foundry being tapped. Molten metal is held in gas fired holding furnaces at the casting operations.

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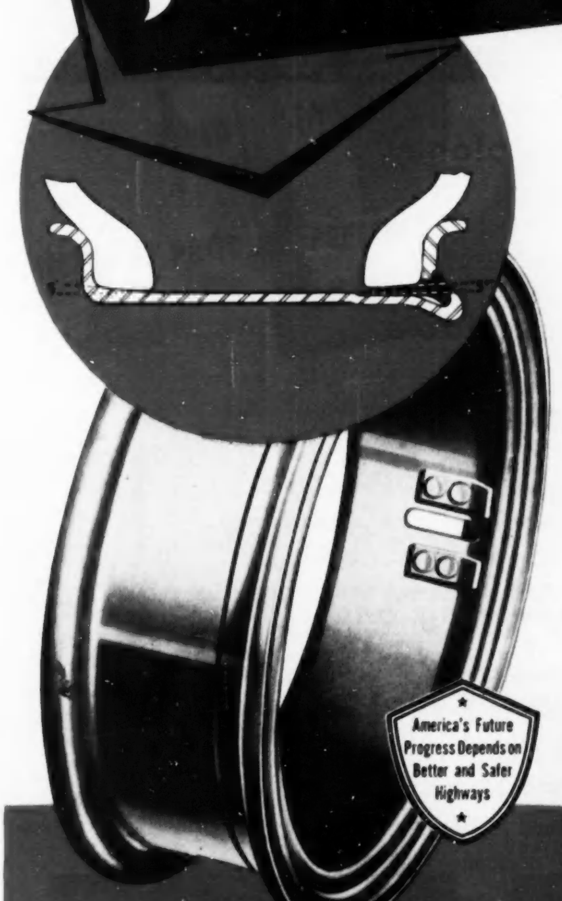
Here's Another Reason Why TRUCK TIRE MILEAGE IS GREATER WITH Firestone ADVANCED RIMS



A truck tire on a Firestone R-5° Advanced Rim sits firmly on the rim with *full width 5-degree solid support* under BOTH beads. This keeps the tire from rocking or wobbling, stops bead chafing and avoids excess body strains. As a result the tire body stays strong and serviceable much longer, providing full original tread mileage plus more retreads than ever before.

Trucks equipped with Firestone R-5° Advanced Rims pay dividends in lower tire costs on every operating mile. No wonder operators are sold on trucks equipped with Firestone R-5° Rims.

Firestone Advanced Rims are available in all sizes in both demountable and non-demountable types. For complete information write to Firestone Steel Products Company, Akron, Ohio.

Here's a Rim That's EXTRA Safe!

The locking ring of the Firestone R-5° Rim is held firmly in place and is actually forced down into the rim gutter by the tire bead as it becomes seated. Even if the side ring is not in place when the tire is inflated, the *locking ring cannot blow off.*

FULL WIDTH 5° TAPERED SUPPORT UNDER BOTH TIRE BEADS

6

Our 6 modern plants

in six separate locations

give you a stabilized, dependable

source for sleeve bearings

and bushings—

and the finest engineering and

field service in the industry is yours

at our sales offices in

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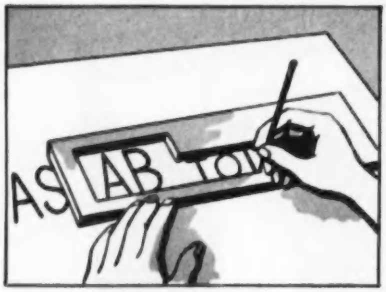
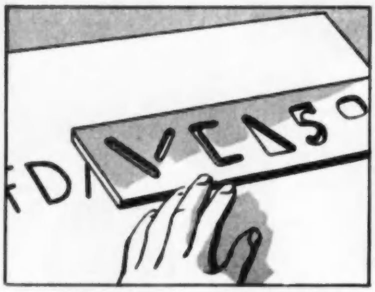
The Cleveland Graphite Bronze Company

DIVISION OF CLEVITE CORPORATION

From freehand to stencil

... this better way of lettering

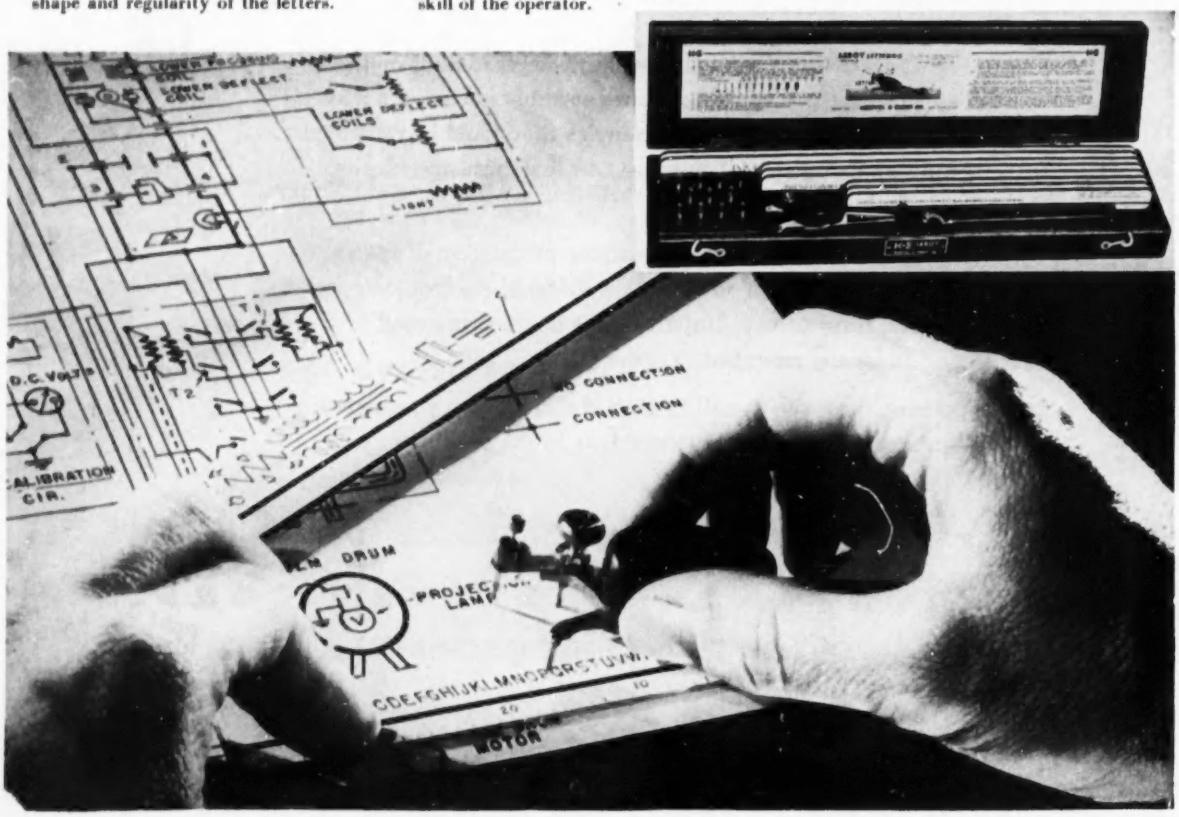




If the results of freehand lettering were always something to be proud of, there would be little or no need of special lettering aids. But as draftsmen know, freehand lettering is often irregular in appearance, and seldom can two men in a department letter exactly alike. Even as simple a device as a height guide helps considerably. Yet it fails in the important function of controlling the shape and regularity of the letters.

An obvious way of controlling shape as well as size is to use a stencil guide. To avoid the broken lines characteristic of stencils, guides were first devised consisting of cut-out portions of letters which could be combined to compose complete letters. However, they covered the work in progress, obscuring it from view, and the appearance of the finished lettering still depended largely on the skill of the operator.

To afford greater control, a stencil guide was developed on which all but a few letters were complete in outline. Shifting the guides with a shuttling motion permitted the breaks in the lines to be filled in. Like all stencils, these too covered up the lettering, and they also had to be supported slightly above the drawing surface so they could be shifted without smearing the work.



Drive-in Deep Freezer Tests Aluminum Automotive Products

40° below zero cold room serves designers and project engineers

Arctic temperatures, homemade in Alcoa's laboratories, sped aluminum piston development. Many aluminum pistons were tested by parka-clad Alcoa engineers for cold-scuffing, noise-level, and expansion characteristics. Now, aluminum pistons are standard equipment in all '53 makes.

Alcoa's frigid proving ground helped meet Army deadlines for a new tank crankcase . . . clipped weeks from the development time of new valve lifters . . . found the cold-weather starting secrets of foreign diesel engines.

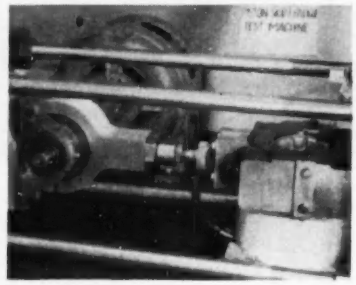
Like all of Alcoa's research and development facilities, our drive-in deep freezer is available to help you apply aluminum's advantages to your automotive product. To get in touch with the Alcoa engineering specialists in your field, call the nearest Alcoa sales office. Or write directly to us, outlining the project you have in mind.

Alcoa Aluminum

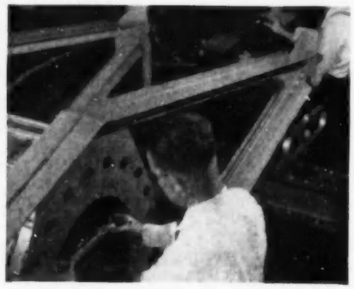
ALCOA ALUMINUM ®

ALUMINUM COMPANY OF AMERICA

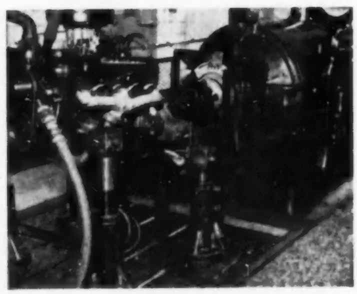
ARE YOU TAKING ADVANTAGE OF THESE FACILITIES?



Development work on aluminum pistons continues with fatigue tests on this special machine built by Alcoa.



Engineering specialists conducting torsion tests of a stiffened aluminum alloy cylinder.



One of Alcoa's battery of dynamometers for testing internal combustion engines.

ALUMINUM COMPANY OF AMERICA
1844-F Alcoa Building
Pittsburgh 19, Pa.

Please send me a copy of your "Road Map to a Better Product" outlining Alcoa's research and development facilities.

Name____________________

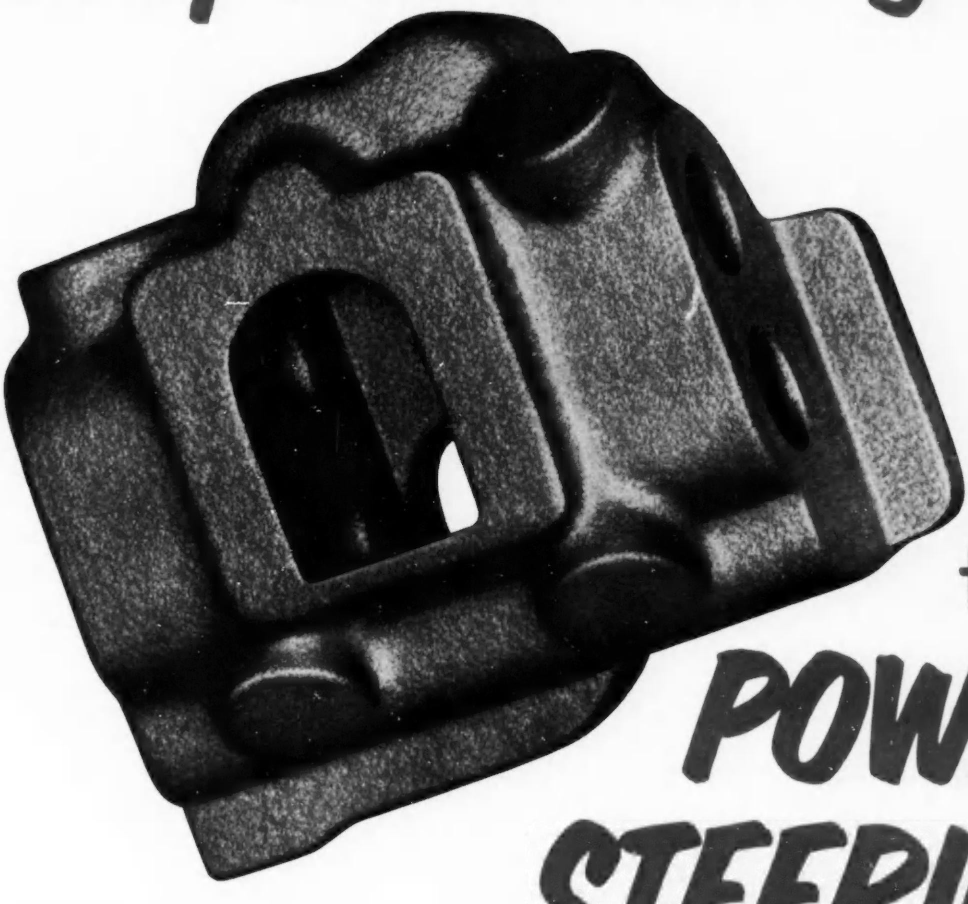
Address____________________

Company____________________

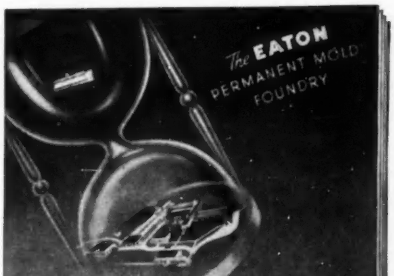
City____________________

State____________________

Eaton Permanent Mold Gray Iron Castings–



for POWER STEERING



Send for your free copy of the 32-page illustrated booklet: "The Eaton Permanent Mold Foundry." It tells the story of Permanent Mold Castings and takes you on a picture-tour of the Eaton Foundry at Vassar, Michigan.

EATON MANUFACTURING COMPANY

General Offices: CLEVELAND, OHIO

FOUNDRY DIVISION: 9771 FRENCH ROAD • DETROIT 13, MICHIGAN

PRODUCTS: Sodium Cooled, Poppet, and Free Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps • Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater-Defroster Units • Snap Rings Springtites • Spring Washers • Cold Drawn Steel • Stampings • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers


STUB TYPE
BARREL TYPE
(REMOVABLE UNIT)
EATON
HYDRAULIC
VALVE
LIFTERS
MUSHROOM TYPE FOR
O H V ENGINES
MUSHROOM TYPE
BARREL TYPE
(INTEGRAL UNIT)

the extra BRAKING ECONOMY proven here...

High in the Rockies Crossing the Continental Divide.

Cost Cutting Bendix-Westinghouse Air Brakes Reduce Downtime and Repairs on Rugged Mountain Runs!

When a braking system proves itself for **safe, dependable performance and low operating costs** day after day over one of the toughest trucking routes in the country its got to be good! And that's exactly what Bendix-Westinghouse Air Brakes do on hundreds of trucks operating over Colorado's Berthoud Pass which cuts through the rugged Rocky Mountains at altitudes exceeding 11,000 feet. Here these **mighty brakes** are put to a grueling test—mile after mile of steep downgrades and sharp, tight curves that require almost constant braking application. Yet here, actual fleet records testify year after year that Bendix-Westinghouse Air Brakes pay off not only with **peak performance, positive control and utmost reliability,** but with actual hard cash savings on maintenance, parts replacement costs and reduced downtime. That's why, no matter what type trucks or busses you build and whether they're designed for operation across town or cross country, you can give your customers the most in performance and profits by specifying the **brakes proven for economy**—Bendix-Westinghouse, the world's most tried and trusted air brakes!

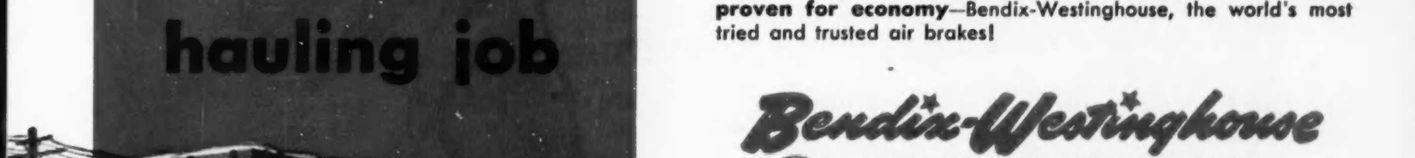
...means MORE PROFITS on any hauling job

Bendix-Westinghouse

THE WORLD'S MOST TRIED AND TRUSTED

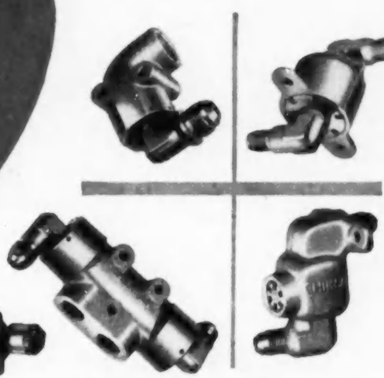
AIR BRAKES

BENDIX-WESTINGHOUSE AUTOMOTIVE AIR BRAKE COMPANY • ELYRIA, OHIO • BERKELEY, CALIF.



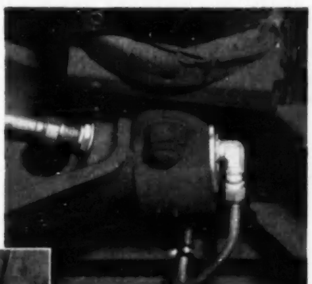
BOEING'S B-52 *Heavyweight Champ* OF JETS

has CHIKSAN Aero-Hydraulic Swivel Joints

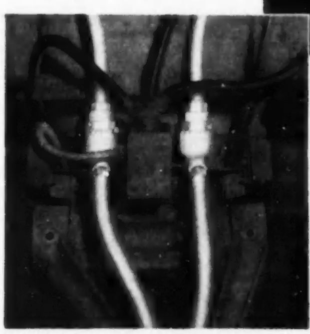


CHIKSAN Hydraulic Aircraft Swivel Joints will handle pressures ranging from 1000 psi to 3000 psi.

CHIKSAN Aero-Hydraulic Swivel Joints and Assembly used on the Boeing B-50 braking system.



CHIKSAN Aero-Hydraulic Swivel Joints and Assemblies for 1000 to 3000 psi systems surpass all standards set down for both civilian and military use.



CHIKSAN low torque joints are also used in conjunction with rubber hose. This combination, utilizing the CHIKSAN swivel action at end of hose, provides flexibility and reduces kinking, twisting, and tearing of the hose.

Boeing's complete confidence in CHIKSAN Aero-Hydraulic Swivel Joints and Assemblies has been previously demonstrated by their selection, in the past, for the B-47 and B-50.

This confidence is further confirmed by Boeing's inclusion of CHIKSAN Swivel Joints and Assemblies in the new B-52 Stratofortress—an eight-jet heavyweight in the heavy bomber division.

Each airframe manufacturer's requirements become the subject of specialized study by CHIKSAN'S Engineering, Research and Development Division. Hydraulic Joints and Assemblies are designed to meet your individual requirements. Designs for all types of aircraft applications are available for handling hydraulics, fuels, oils, water, air, oxygen and other fluids.

The Flow of Enterprise Relies on

CHIKSAN

Ball-Bearing Swivel Joints

Write CHIKSAN today for Catalog 2A "Aircraft Swivel Joints" — Dept. SJ-6

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Model 5-C-720
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You write the Specifications!
Model 5-A-620
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TRANSMISSIONS
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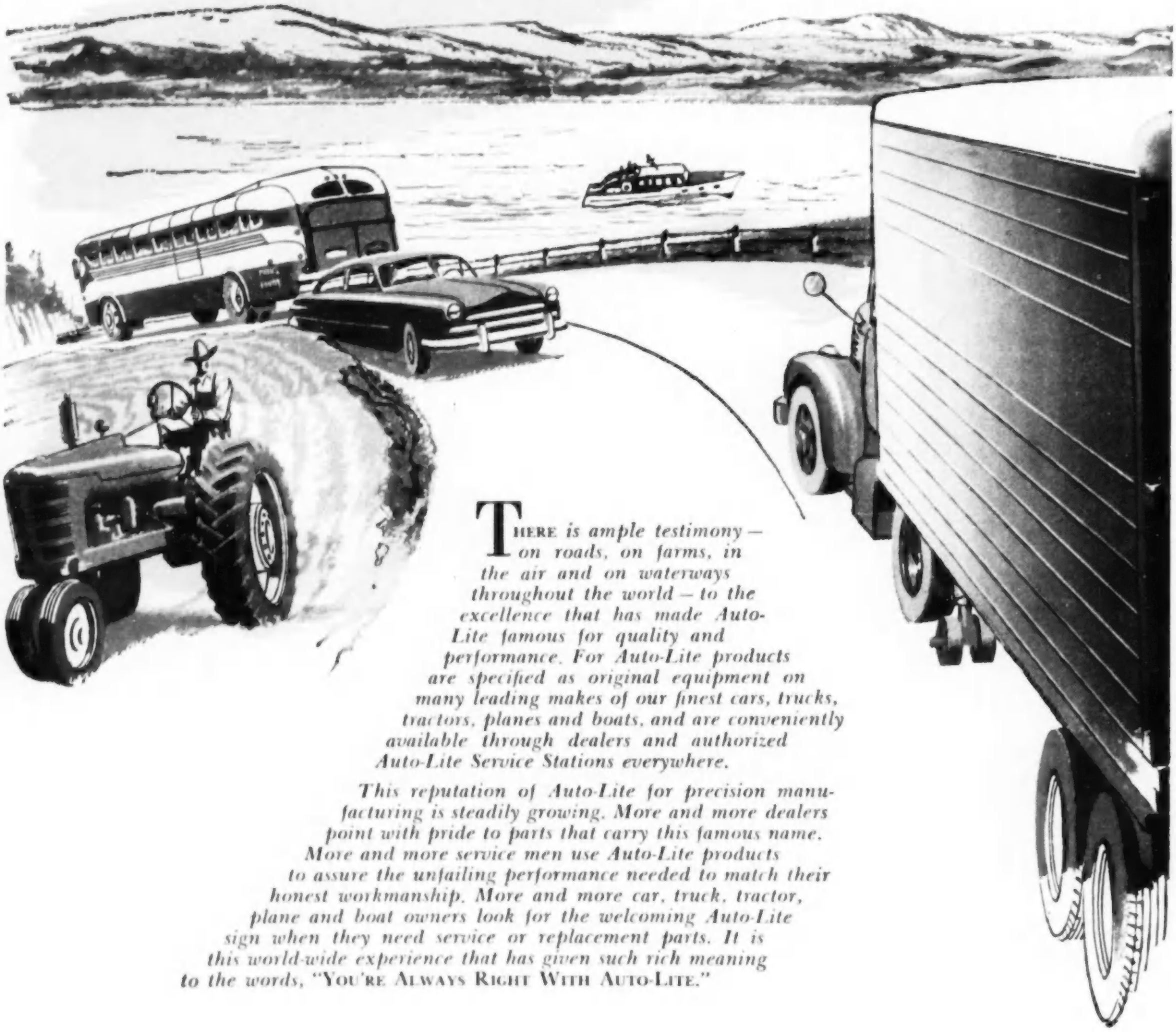
Serving the world's constant demand for better transportation!



There is ample testimony — on roads, on farms, in the air and on waterways throughout the world — to the excellence that has made Auto-Lite famous for quality and performance. For Auto-Lite products are specified as original equipment on many leading makes of our finest cars, trucks, tractors, planes and boats, and are conveniently available through dealers and authorized Auto-Lite Service Stations everywhere.

This reputation of Auto-Lite for precision manufacturing is steadily growing. More and more dealers point with pride to parts that carry this famous name. More and more service men use Auto-Lite products to assure the unfailing performance needed to match their honest workmanship. More and more car, truck, tractor, plane and boat owners look for the welcoming Auto-Lite sign when they need service or replacement parts. It is this world-wide experience that has given such rich meaning to the words, "You're Always Right With Auto-Lite."

AUTO-LITE *Manufacturers of...*

BATTERIES • BUMPERS • FUEL PUMPS • HORNS • GENERATORS
LIGHTING UNITS • SPEEDOMETERS • SPEEDOMETER CABLE
SWITCHES • STARTING MOTORS • INSTRUMENTS & GAUGES
IGNITION UNITS • MOULDED PLASTICS • WINDSHIELD WIPERS
WINDOW LIFTS • SEAT MOVING MECHANISMS • HUB CAPS
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ASSEMBLIES • GRAY IRON CASTINGS • ZINC &
ALUMINUM BASE DIE CASTINGS

WORLD'S LARGEST INDEPENDENT MANUFACTURER OF AUTOMOTIVE ELECTRICAL EQUIPMENT

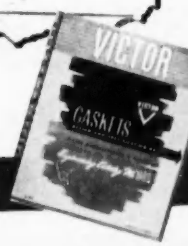
Sealing Data you've never had before

Here are the SAE-ASTM Gasket Material Specifications	Here are the SAE-ASTM Material Classifications	And here is the VICTOR EQUIVALENT of each item
	Class 1 — Natural and/or Synthetic Rubber and Asbestos (Compressed)	
	Group 2 — Oil Resistant	
G-1121	Item 1 — Med. Temp. & Max. Oil & Aromatic Fuel Resistance (SA)	Victopac #1
G-1122	Item 2 — Max. Temp. & Good Oil & Aromatic Fuel Resistance (SB)	Victopac #50-V
G-1123	Item 3 — Max. Temp. & Fair Oil & Aromatic Fuel Resistance (SC)	Victopac #60-V
	Class 4 — Natural and/or Synthetic Rubber and Fiber	
	Group 2 — Oil Resistant	
G-1422-1 G-1422-2	Item 2 — Max. Temp. & Good Oil & Aromatic Fuel Resistance (SB)	Asbestopac #221 Asbestoprene #222
G-1423-2 G-1423-3	Item 3 — Max. Temp. & Fair Oil & Aromatic Fuel Resistance (SC)	Asbestopac #232 Asbestoprene #233
	Class 5 — Natural and/or Synthetic Rubber and Miscellaneous Fillers	
	Group 2 — Oil Resistant	
G-1523-3	Item 3 — Max. Temp. & Fair Oil & Aromatic Fuel Resistance (SC)	Victolene S
	Class 2 — Treated Paper	
	Group 1 — Gelatin and/or Synthetic Resin	
G-3211	Item 1 — Max. Oil, Water and Gasoline resistant	Victorite B
G-3212	Item 2 — Good Oil, Water and Gasoline resistant	Victorite B
G-3213	Item 3 — Fair Oil, Water and Gasoline resistant	Victorite G
	Group 2 — Gelatin and/or Synthetic Resin Impregnated Compositions (Wood, Cork, Leather, etc.)	
G-3222	Item 2 — Good Oil, Water and Gasoline resistant	Victorite R
	Group 4 — Natural and/or Synthetic Rubber Impregnated Compositions (Wood, Cork, Leather, etc.	
G-3242		

On non-metallic gasket materials for general automotive and aeronautical purposes, Victor now gives design engineers a valuable service not available heretofore. Above is a partial list of such packings in the new Victor Gasket Catalog. Note how each material is clearly classified by grade equivalence to standard SAE-ASTM specifications. And besides, Victor gives you precise application data on each grade of product.

You'll save much time by using the new Victor Catalog. More important, it will help you assure dependable and economical sealing specifications. Talk it over with your Victor Field Engineer.

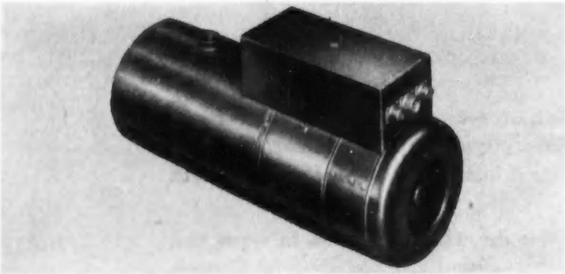
Victor Mfg. & Gasket Co., P. O. Box 1333, Chicago 90, Ill.



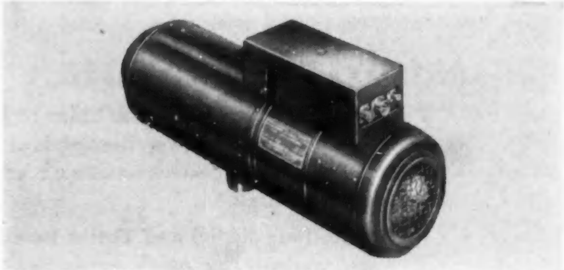
Your New Complete Guide to Gasket Materials
VICTOR ENGINEERING CATALOG No. 505
Supplied to Design Engineers by request on business letterhead.

VICTOR GASKETS • PACKINGS • OIL SEALS
SEALING PRODUCTS *EXCLUSIVELY*

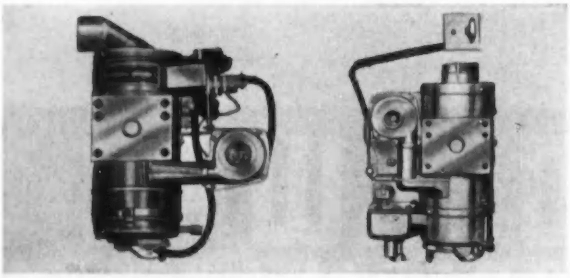
When the chips were down



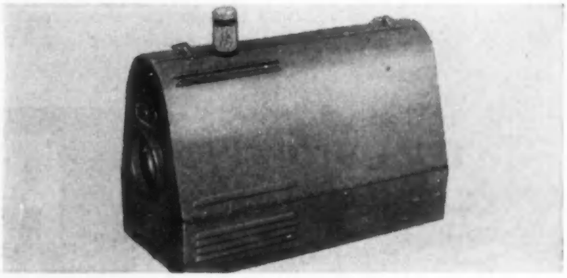
Model E-511 Coolant Heater for liquid-cooled gasoline and diesel engines. Puts 60,000 B.t.u. per hour into coolant.



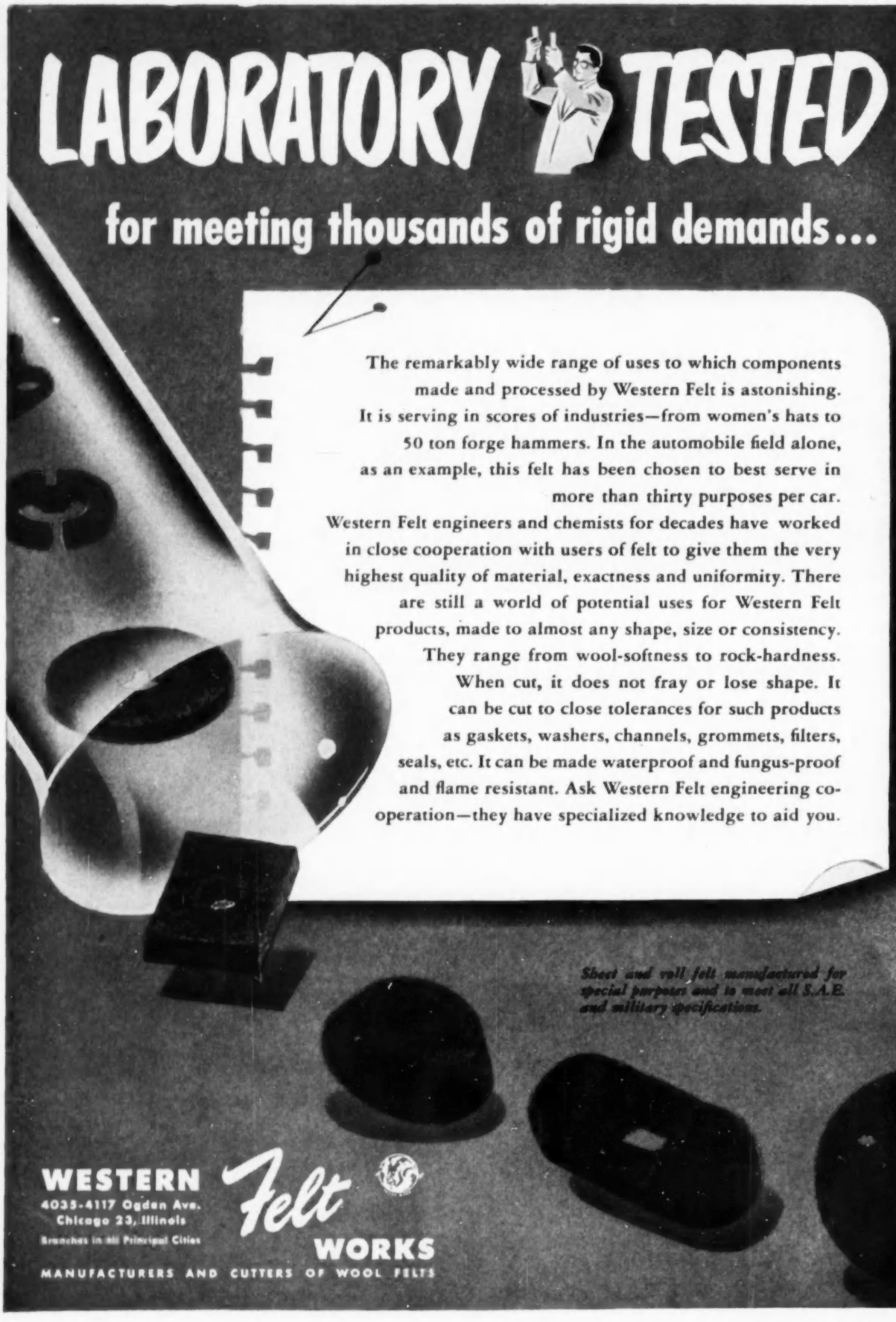
Model E-510. Fresh-Air Heater. 60,000 B.t.u. per hour. Delivers more *actual fresh-air heat* than any other unit of this type. Designed for engine, cargo, personnel heating.



Series 460 and Series 590. Coolant and Direct-Fired Engine Heaters. Each heater is a complete package requiring only electric, fuel, coolant and exhaust connections.



Model E-600 Portable Heater. 60,000 B.t.u. fresh-air output. Meets the need for a complete heating unit that is easily portable. Operates on 110 V.


LABORATORY TESTED
for meeting thousands of rigid demands...
The remarkably wide range of uses to which components made and processed by Western Felt is astonishing. It is serving in scores of industries—from women's hats to 50 ton forge hammers. In the automobile field alone, as an example, this felt has been chosen to best serve in more than thirty purposes per car. Western Felt engineers and chemists for decades have worked in close cooperation with users of felt to give them the very highest quality of material, exactness and uniformity. There are still a world of potential uses for Western Felt products, made to almost any shape, size or consistency. They range from wool-softness to rock-hardness. When cut, it does not fray or lose shape. It can be cut to close tolerances for such products as gaskets, washers, channels, grommets, filters, seals, etc. It can be made waterproof and fungus-proof and flame resistant. Ask Western Felt engineering co-operation—they have specialized knowledge to aid you.
Sheet and roll felt manufactured for special purposes and to meet all S.A.E. and military specifications.
WESTERN Felt WORKS
4035-4117 Ogden Ave.
Chicago 23, Illinois
Branches in All Principal Cities
MANUFACTURERS AND CUTTERS OF WOOL FELTS

Send for free print

First four-wheeled Benz, the "Victoria," had exposed chain drive, three-piece front axle with main shaft and two steering knuckles, vertical one-cylinder motor. Triple carriage lamps provided good illumination. The year—1893.

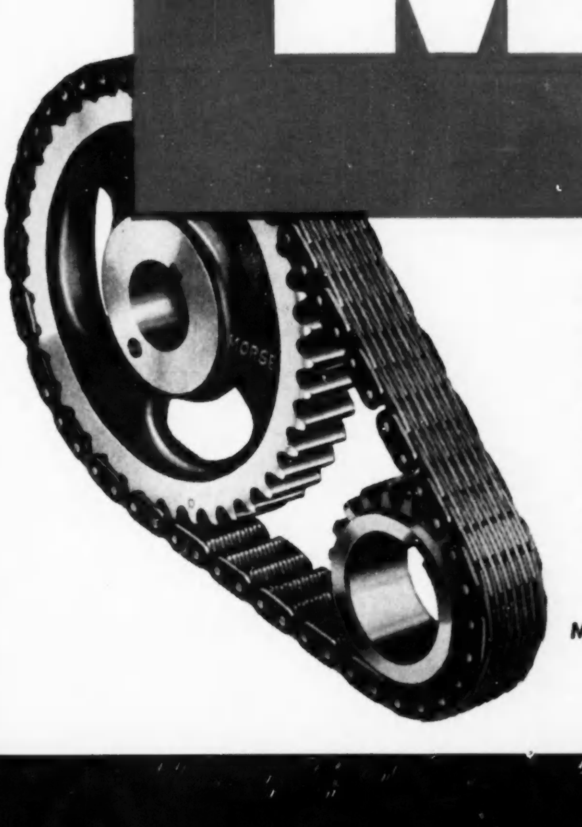
This is one of a series of antique automobile prints that will appear in future Morse advertisements. Write for your free, enlarged copy, suitable for framing for your collection.

What's behind the equation

M=TC

Morse *means* Timing Chains

for YOU



There's much. For example:

1. You get timing-chain drives of unmatched dependability, *proved* by the fact that eleven of the thirteen cars now using timing-chain drives use Morse Timing Chain Drives as original equipment.

2. You get—and can rely on—customer-conscious delivery that moves our chains and sprockets to you right on schedule.

3. You can take advantage of the specialized technical and engineering skills that have helped many manufacturers whip problems in timing-chain design, development, and application.

Call or write us for information on your timing-chain problems. We'll be glad to *show* you, in short order, why M=TC; Morse *means* Timing Chains—and what's behind that equation for you.

MORSE

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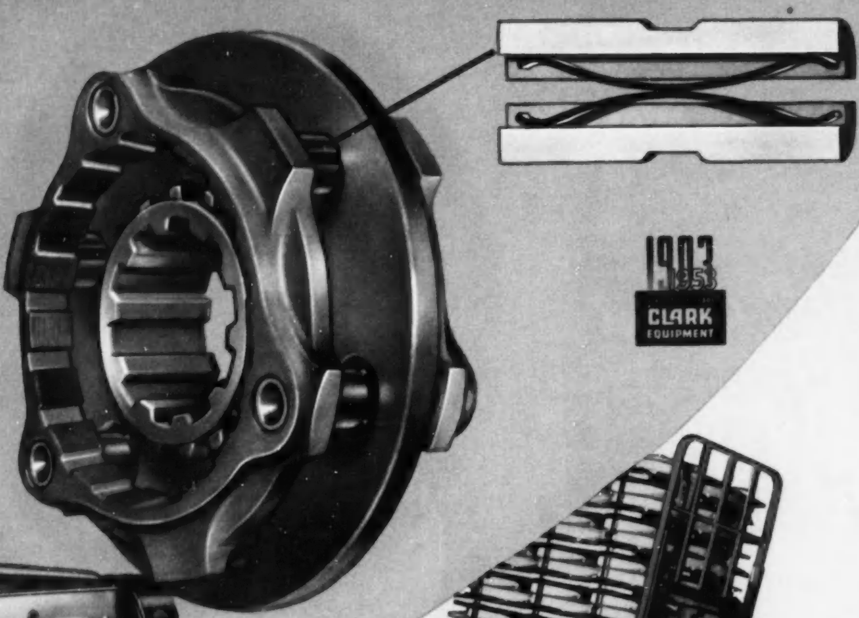
1903
1953
FIRST FIFTY YEARS
CLARK
EQUIPMENT
CLARK
Here's a new and practical approach to an old problem . . . Instead of designing a machine to use an axle of existing pattern, why not design the machine to meet the necessities of its job—and then design a power-transmission especially for that machine. That's what Clark does; and that's why "working with Clark" appeals strongly to a growing list of equipment manufacturers—automotive, agricultural, industrial.
Turn and see reverse side for more about CLARK products
CLARK EQUIPMENT COMPANY, Buchanan, Michigan
Other Plants: BATTLE CREEK AND JACKSON, MICHIGAN

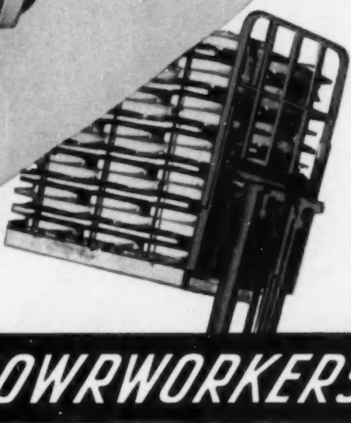
The NEW CLARK SPLIT-PIN SYNCHRONIZER

CLARK transmissions are now available featuring THE "SPLIT-PIN" SYNCHRONIZER. In keeping with its traditional enthusiasm for engineering development, Clark not only builds a full range of conventional models, but specializes in designing and producing transmissions for unusual requirements for trucks, busses, farm tractors, industrial trucks and road building machinery.

Write for Products Booklet.

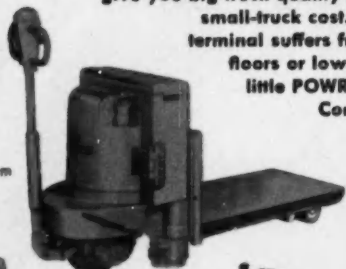


1903 1953 CLARK EQUIPMENT



CLARK *POWRWORKERS*

POUND FOR POUND, dollar for dollar, you can't beat the value in CLARK'S POWRWORKER Line. They'll give you big-truck quality performance at rock-bottom, small-truck cost. If your warehouse, dock or terminal suffers from narrow aisles, low-load floors or low-clearance—then the rugged little POWRWORKERS are just what the Comptroller ordered to cut your handling costs. Write for Material Handling News.



Platform Truck

Stacker

Pallet Truck

Tug Tractor

Products — TRANSMISSIONS • AXLE HOUSINGS • GEARS and FORGINGS • TRACTOR UNITS • FORK TRUCKS and TOWING TRACTORS • FRONT and REAR AXLES for TRUCKS and BUSSES

CLARK EQUIPMENT COMPANY
BUCHANAN, MICHIGAN
Other Plants: Battle Creek and Jackson, Michigan

1953 Mobilgas Economy Run Proved Again

B-W Overdrive *pays off!*

Top 9 cars (on miles-per-gallon basis) including Sweepstakes winner—*all equipped with this famous Borg-Warner Transmission unit—averaged*

25.27 MILES PER GALLON

Again this year the records proved: B-W Overdrive means more miles per gallon of gas!

In the grueling, 1206.1-mile Mobilgas Economy Run—sanctioned and supervised by the Contest Board of the AAA—the 9 best actual miles-per-gallon records were made by 1953-model cars equipped with Borg-Warner Overdrive.

And in *every* year of this annual contest, the *ton-miles-per-gallon* Sweepstakes winner has been equipped with this famous Borg-Warner transmission unit.

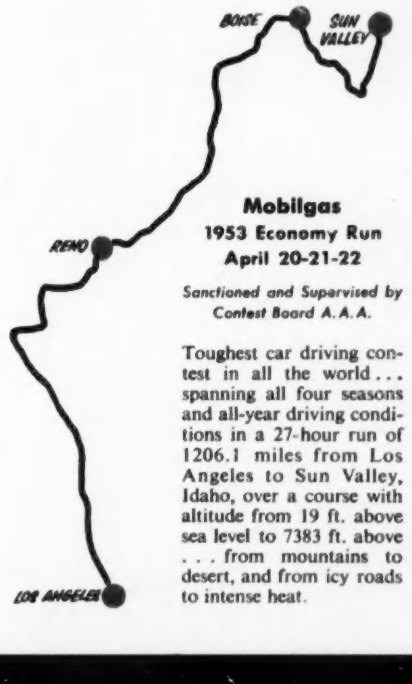
What better proof could you want of real fuel economy!

SAVES GAS—CUTS ENGINE WEAR

An advanced-type transmission, B-W Overdrive automatically cuts engine revolutions 30%. At 50, for instance, the engine is taking it easy at only 35! That saves gas. Saves engine wear, too—means longer life and fewer repair bills.

Made exclusively by B-W's Warner Gear Division, Overdrive is now offered on 13 leading makes of cars. Proof again that . . . *B-W engineering makes it work—B-W production makes it available.*

Borg-Warner



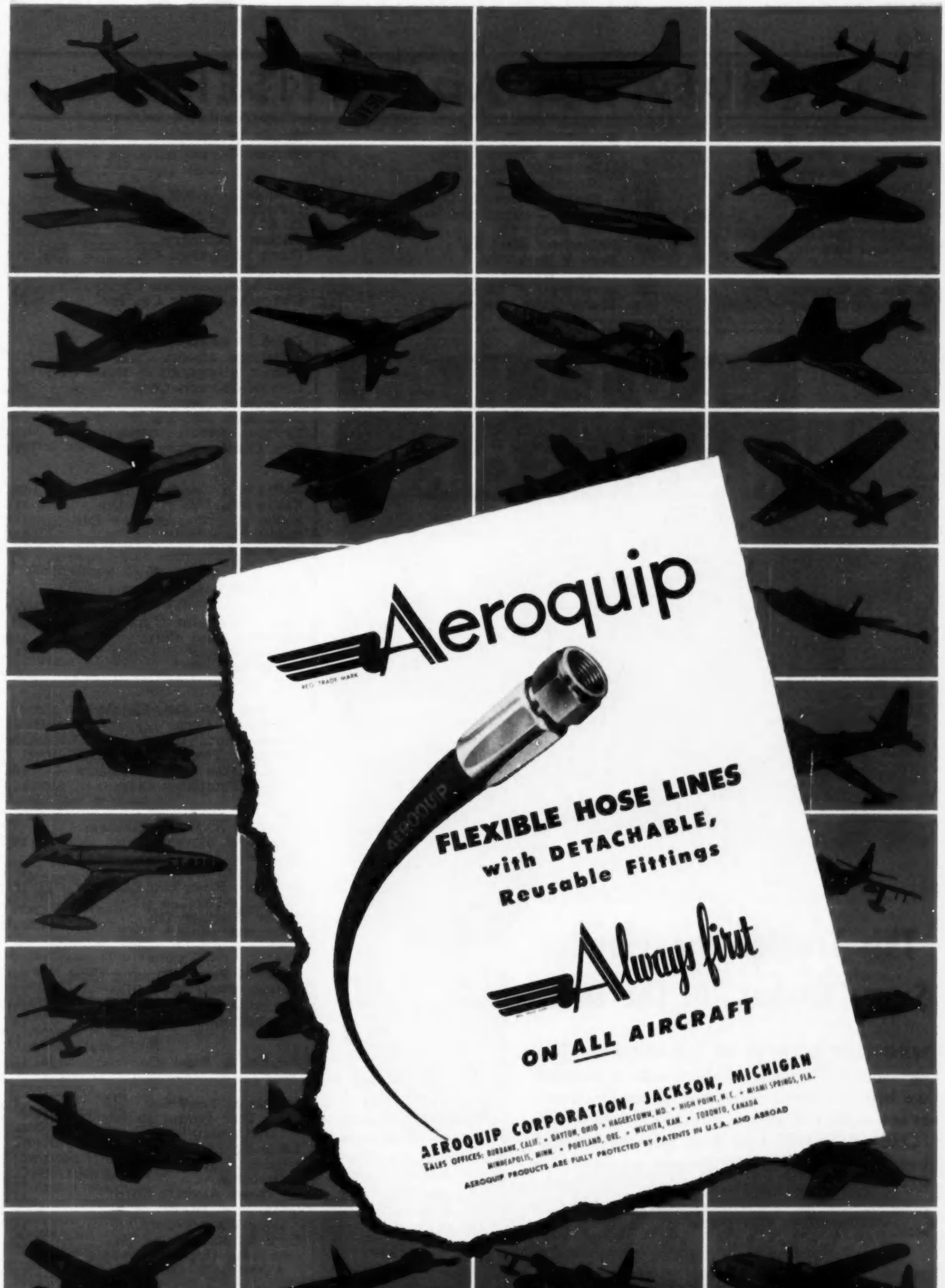
Mobilgas 1953 Economy Run April 20-21-22

Sanctioned and Supervised by Contest Board A. A. A.

Toughest car driving contest in all the world . . . spanning all four seasons and all-year driving conditions in a 27-hour run of 1206.1 miles from Los Angeles to Sun Valley, Idaho, over a course with altitude from 19 ft. above sea level to 7383 ft. above . . . from mountains to desert, and from icy roads to intense heat.

ENGINEERING B-W PRODUCTION

THESE UNITS FORM BORG-WARNER, *Executive Offices, Chicago:* ATKINS SAW • BORG & BECK • BORG-WARNER INTERNATIONAL • BORG-WARNER SERVICE PARTS • CALUMET STEEL • CLEVELAND-COMMUTATOR • DETROIT GEAR • FRANKLIN STEEL • INGERSOLL PRODUCTS • INGERSOLL STEEL LONG MANUFACTURING • LONG MANUFACTURING CO., LTD. • MARBON • MARVEL-SCHEBLER PRODUCTS • MECHANICS UNIVERSAL JOINT • MORSE CHAIN MORSE CHAIN CO., LTD. • NORGE • NORGE HEAT • PESCO PRODUCTS • REFLECTAL • ROCKFORD CLUTCH • SPRING DIVISION • WARNER AUTOMOTIVE PARTS • WARNER GEAR • WARNER GEAR CO., LTD. • WOOSTER DIVISION



Aeroquip
FLEXIBLE HOSE LINES
with DETACHABLE,
Reusable Fittings
Always first
ON ALL AIRCRAFT
AEROQUIP CORPORATION, JACKSON, MICHIGAN
SALES OFFICES: BURBANK, CALIF. • DAYTON, OHIO • HAGERSTOWN, MD. • HIGH POINT, N. C. • MIAMI SPRINGS, FLA.
MINNEAPOLIS, MINN. • PORTLAND, ORE. • WICHITA, KAN. • TORONTO, CANADA
AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A. AND ABROAD

+ INDEX TO ADVERTISERS +

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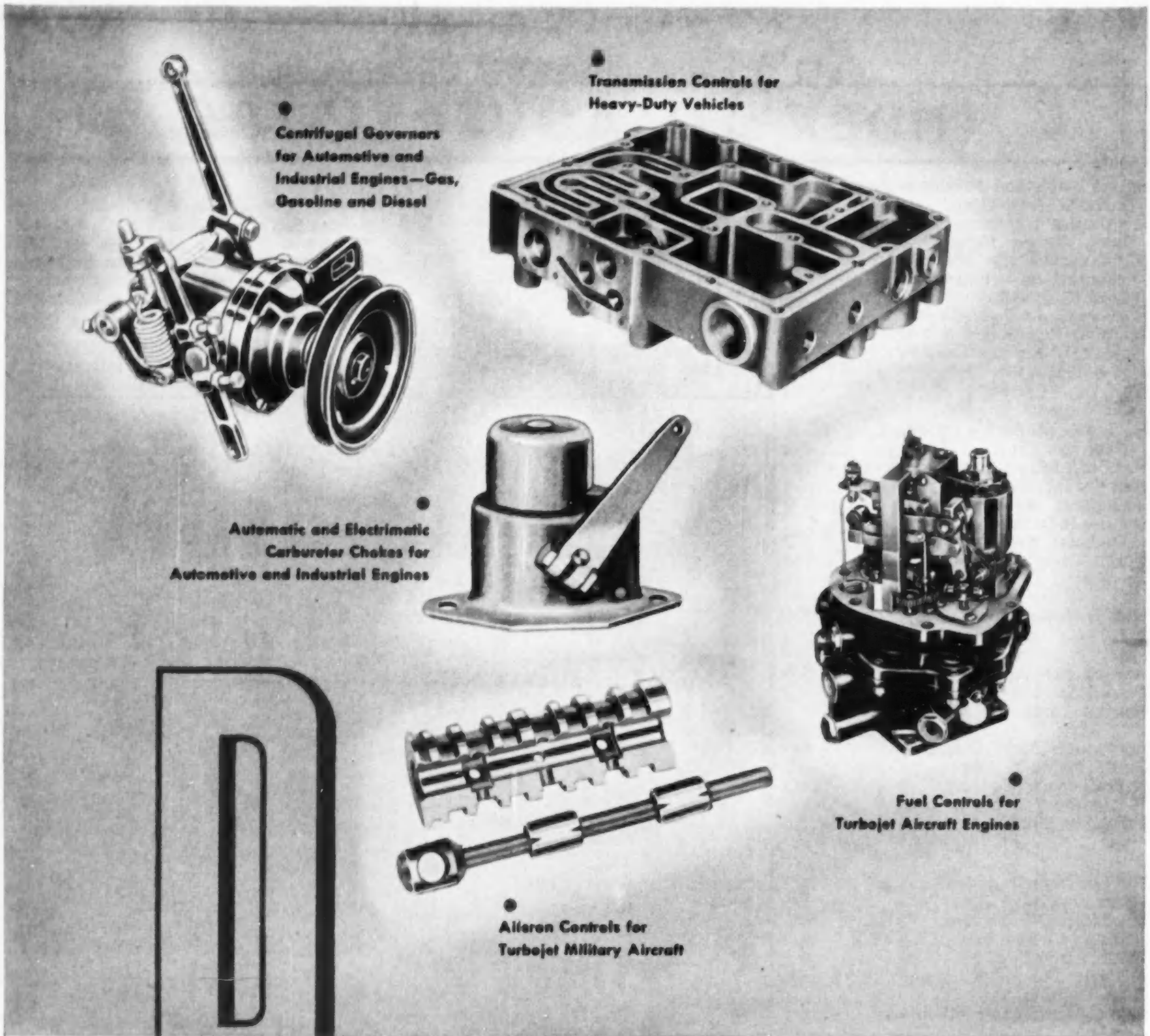
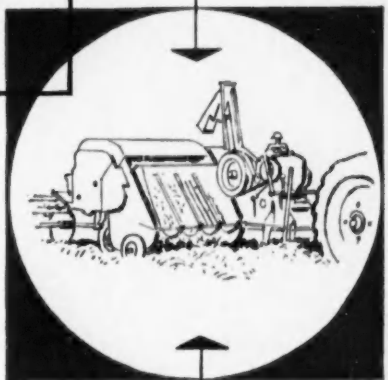

Centrifugal Governors for Automotive and Industrial Engines—Gas, Gasoline and Diesel
Transmission Controls for Heavy-Duty Vehicles
Automatic and Electrimatic Carburetor Chokes for Automotive and Industrial Engines
Fuel Controls for Turbojet Aircraft Engines
Aileron Controls for Turbojet Military Aircraft

"IRON CURTAINS"

TO KEEP OUT SABOTEURS OF FARM EQUIPMENT

Grease Shield | Felt Seal | Plya-Seal | Mechani-Seal

(Various combinations of seals and shields are also available.)



Dust, dirt, excessive temperature changes and moisture can't sabotage vital turning points on farm machinery equipped with Fafnir Sealed or Shielded Ball bearings. These "Iron Curtain" bearings keep machinery operating smoother, longer, without attention or breakdowns even though it's idle or neglected for long periods.

Four basic types of sealed and shielded Fafnir bearings are designed to meet practically all requirements . . . from the exclusion of coarse dirt or chips to complete protection against the loss of lubricant and entrance of foreign matter.

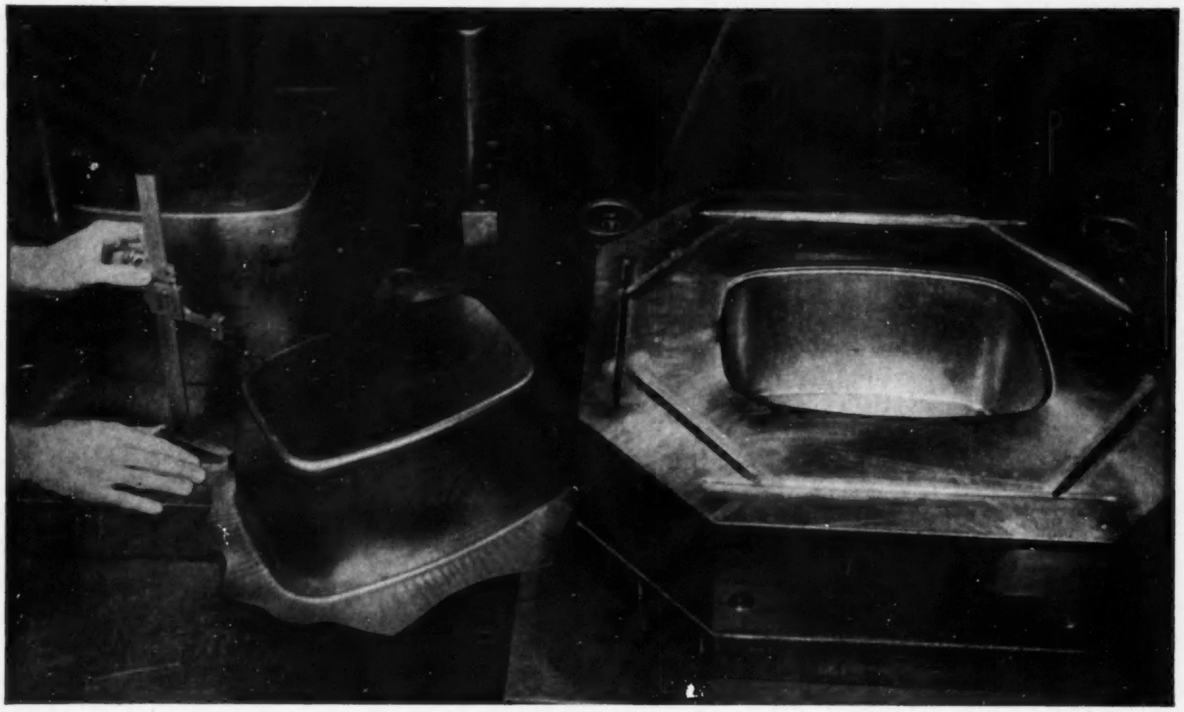
Better, longer performance isn't the only advantage of Fafnir Ball Bearings with "Iron Curtains". Manufacturing costs can be cut, assemblies simplified, and machining operations eliminated. To find out what advantages Fafnir Sealed and Shielded Bearings can offer you, call in a Fafnir Representative. The Fafnir Bearing Company, New Britain, Conn.

FAFNIR

BALL BEARINGS

MOST COMPLETE LINE IN AMERICA

Graph-Mo® steel die draws contour shell 5⅞" deep without scoring!



TO keep production up and finishing costs down when deep drawing contour shells for home fryers, the Dickey Grabler Company, Cleveland, Ohio, uses dies made of Graph-Mo®—one of four Timken® graphitic tool steels.

Because of the free graphite in its structure, Graph-Mo has outstanding low-friction properties: minimum tendency to score, seize, scuff or gall. As a result, Graph-Mo dies make the difficult 5⅞" deep contour draw without scoring the stamping. Costly polishing before the chrome-plating operation is eliminated, die life increased.

Graph-Mo offers other die advantages, too. The diamond-hard carbides in Graph-Mo give excellent resistance to wear and abrasion. It responds uniformly to heat-treatment, permitting closer tolerances in the parts. It has good stability, and is easier to machine than ordinary tool steels.

For more helpful information on the four Timken graphitic tool steels and their uses in dies, punches, gages and machine parts, write for the 10th edition of "Timken Graphitic Steel Data Book". The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING